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CANADIAN PSYCHOLOGICAL ASSOCIATION, 1957–1958

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DECISIONS[1]

W. E. BLATZ

University of Toronto

PSYCHOLOGY has always found itself in a battle for survival. Other disciplines have introduced their methods and have attempted to usurp the main goal of psychology, namely the study of the mind. The physiologist, the astronomer, the neurologist, the psychiatrist, the biologist, the geneticist, have all interfered, and now the major threat comes from the mathematician.

Dealing particularly with applications of psychology in the fields of economics and military strategy, the mathematician, with a good deal of ingenuity, has attempted in the past two decades to reduce psychological processes to "models" by which he pretends to analyse decision-making in human beings. Edwards outlined the theory of decision-making in his 1954 review (2), since when the topic has spread into psychological publications from economic and military ones.

Luce and Raiffa state in *Games and Decisions* (3, p. 7): "In many ways social scientists seem to want from a mathematical model more comprehensive predictions of complex social phenomena than have ever been possible in applied physics and engineering. It is almost certain that their desires will never be fulfilled and so either their aspirations will be changed, or formal deductive systems will be discredited for them." The quotation sounds a bit querulous, as of individuals who have set themselves an impossible task and then looked around for a whipping boy. These models, to be sure, apply only to an "economic" man, a "reasonable" man, or a "rational" man, none of whom exists. Luce and Raiffa later say, significantly: "Since exhaustive testing of subjects is impracticable outside the laboratory, if even there, a psychological theory is needed which will allow the prediction of utility functions from a knowledge of the objective pay off and from a relatively few measurements or observations of the subjects" (3, p. 50). It is this challenge which we will take up and attempt to meet by the Theory of Security as it is developing at the Institute of Child Study.

[1] This is a brief abstract of the Presidential Address given at the Annual Meeting of the Canadian Psychological Association, Edmonton, Alta., June 13, 1958. The author does not read from a manuscript, claiming that if the paper is so prepared, it would save time and tempers to pass it out and have each one read at his own rate and convenience.

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Luce and Raiffa are asking for a system of psychology which will explain the vagaries of their mathematical testing device. We can offer them a still reputable technique of psychological investigation, namely, introspection. Through introspective analysis of the phenomenon of decision-making one can readily indicate why it is so difficult to encapsulate a decision in a mathematical formula with only two variables. The schema in Figure 1 suggests that at least ten variables are involved, to varying degrees, in any decision-making episode and, since every moment of consciousness is a decision-making episode, it can easily be seen how complicated a theory of human behaviour must be, whatever its starting point.

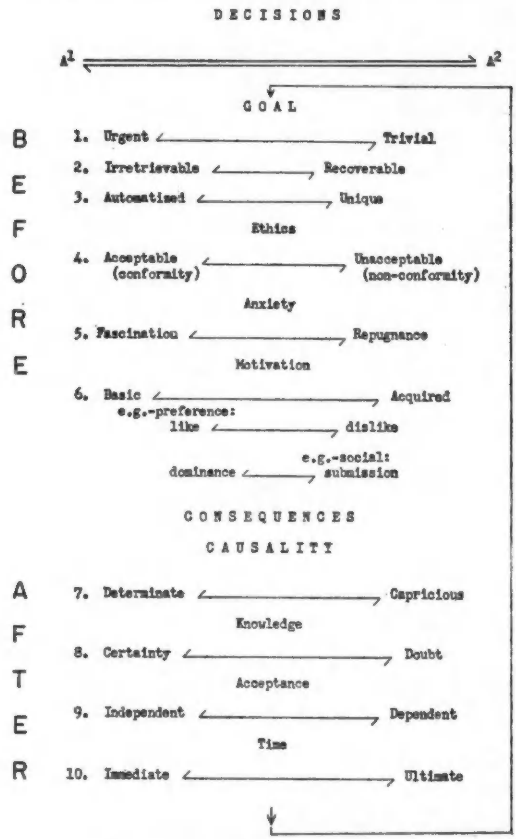

FIGURE 1. Variables in decision-making.

The ten variables in Figure 1 are not necessarily in order of importance. Each of them, as the diagram suggests, represents a possible continuum, for which a three, five, or seven point scale might be constructed. These scales would be about as reliable as such scales usually are. A brief description of each variable will illustrate how an introspective technique yields information.

(1) Decisions are obviously urgent or trivial, depending largely upon a value judgment by the individual concerned. An urgent decision might be the buying of one house or another; a trivial one, whether to put the left or right sock on first.

(2) In a literal sense, no decision can ever be made again. Once made, it becomes part of one's past. But there are decisions which *appear* to be recoverable or revokable, as by exchanging goods at a store, or divorcing after marriage; and others which are clearly irretrievable, such as jumping into space from a plane.

(3) Some decisions have become automatized, such as turning the door knob to enter a room; others are unique, such as the first decision made by a novice in a profession, presented with his first case.

(4) In the area of ethical judgment, the field is wide open. It is unlikely that an individual's attitude towards his fellow-man or his code of ethics is ever absent, however negligible it may appear at times. It may appear dubious that one can place ethics on a seven-point scale—but after all there are venial as well as mortal sins.

(5) One attribute of decision-making is the inevitable feeling of anxiety. It is a mistake, however, to think that anxiety is always unpleasant. To some people indecision can be an exceedingly pleasant experience, as witness the shopping practices of well-to-do consumers, and the tension occasioned by dangerous situations in sport. Gambling, too, is prominent in human behaviour. Of course, there are times when having to make a decision is most unpleasant. Whether decision-making is pleasant or unpleasant for an individual may be a matter of training.

(6) The relative importance of basic as opposed to acquired motives is a subject for long inquiry. Two continua have been indicated. One runs from like to dislike, passing through a point of indifference. (It is interesting that, in the mathematical models proposed in the economic literature, the suggestion is made that indifference may be measured on a continuum. This kind of psychological paradox vitiates much of the significance of the mathematical formulae.) The other continuum is in the area of dominance and submission, two acquired aspects of social behaviour which are difficult to measure, but which are inevitable concomitants of decision-making.

The second main division of the attributes of decision-making is in the field of consequences, which occur, of course, after decision has been made. Once a decision has been made, however, the consequences of that decision are involved in the making of the next one; thus, although the consequences of a decision come later, nevertheless the accumulated experience of consequences is part of the apperceptive mass of the decision-in-making.

(7) Whether the concept of causality is ever expressed in detail or seen clearly as a thesis, an individual always stands somewhere on a teeter-totter, balancing between a concept of the universe that is deterministic and one that is wholly capricious. It is obvious that the decision made at any given time is a function of the individual's position at that time on this scale. Hence the irritated complaint of the mathematician that individuals are not consistent.

(8) With the growth of experience it should be possible to refine and improve one's judgment by reference to the accuracy of one's predictions of the consequences of previous decisions. Whether one's knowledge is adequate or accurate depends on experience and the use of authorities, but this is not nearly as significant an aspect of decision-making as the next variable, namely, acceptance.

(9) The acceptance or attempted rejection of consequences becomes a highly significant aspect of decision-making very early in life, and it is in this area that the impact of decision-making on personality is most apparent. It is with this variable as the starting point that the schema of security, shown in Figure 2 has emerged, although the other variables were taken into account as well.

(10) The more immediate the consequences of an act as envisaged by a decider, the more likely he is to refine his judgment and learn, either to accept the consequences or to modify his decision. Some consequences, however, are projected far into the future—indeed, into infinity, as with eternal punishment. This tends to impede learning. One reason for a student's failure at university, for example, may be his inability to project the consequences of his present behaviour to a point even four years hence.

Whether or not these ten variables exhaust decision-making is a matter for research. The challenge that we hand to the mathematician is to take these ten variables, arrange the continua so that the intervals are equal, and then construct a model, which will predict what an individual (not a *group*) will do (not *may* do) in a specific situation. After all, the physicist had only three variables—energy, mass and velocity!

Out of these variables, however, it is possible to attempt to understand human behaviour and to construct a model—though not a mathematical

one, or even a spatial one. The concept of security outlined in Figure 2 is such a model. It has been described fully elsewhere (1), and here only a brief synopsis will be given.

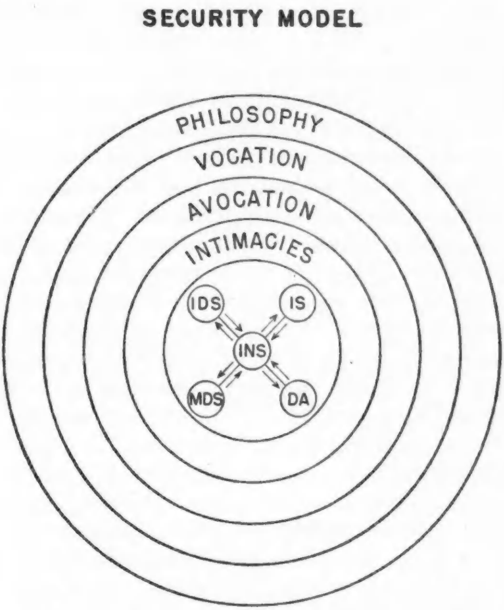

FIGURE 2. Diagram of security development. IDS: immature dependent security; INS: insecurity; IS: independent security; MDS: mature dependent security; DA: deputy agents.

According to the thesis, security is a state of mind in which one is willing to accept the consequences of one's behaviour. From this starting point, one can envisage an infant, at first wholly dependent upon an agent, feeling secure because the agent is responsible for his decisions. This is *immature dependent security*. From this state he gradually emerges into a state of insecurity, and hence anxiety, from which he can extricate himself, if he so wishes, in one of four ways: first, by reverting to the state of immature dependent security, a regressive mechanism which is wholly salutary in infancy and depends for its efficacy upon the adequacy of the "immature agent" (usually the parent); secondly, through a process of expending effort, he may learn, acquire knowledge, accept consequences and hence becomes *independently secure*; thirdly,

to bolster up his inadequacy, (which is the gap between his own knowledge and omniscience) he may acquire a "mature agent" in terms of an intimate outside his family who serves in lieu of the "immature agents" from whom he has emancipated himself; this is *mature dependent security*. The fourth device for avoiding insecurity is to employ a *deputy agent*. These agents are the behaviour patterns that have been called neurotic. They encompass all those mechanisms which are listed under psychopathological signs—hysteria, mania, paranoia, etc.

It is suggested in this thesis that these deputy agents are manifest in all children (as can be readily observed); that as the child grows up he learns to lean on some which he has considered successful in dealing with his insecure states; and that all adults manifest in times of crisis or semi-crisis their chosen deputy agents, which in turn become more and more automatized. It is further suggested that mental illness is the pattern of behaviour that an individual manifests when he has succumbed to these devices for dealing with insecurity, instead of acquiring independent security or mature dependent security. Mental illness is a generic term, and is not made up of the specific disease entities included in the psychiatric nosology.

Furthermore, with this security model in mind, it can be seen that the growing child develops patterns of security and dependency first in the area of intimacies, in the family, and later outside it. At about four or five, his interests begin to solidify (avocation); then, at eight or nine, he has more or less accepted the routine requirements of an environment (vocation); and finally, after nine (mental age), he begins to acquire a philosophy in which the concept of purpose first emerges.

This schema is far removed from the seemingly precise and aesthetic mathematical model of the statistician, but it is, I think, closer to the core of human behaviour.

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SENSORY TRANSMISSION MECHANISMS[1]

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WHAT A SUBJECT reports that he perceives never entirely corresponds to the pattern of excitation of his receptors. This observation is not based on direct experiment, since no patterns of receptor activity have been measured in subjects who were at the same time giving introspective reports. Most of the evidence comes from comparison of the activity of receptors in anaesthetized animals with reports of human subjects receiving similar sensory stimulation. However, in the case of vision we can calculate from the optical characteristics of the eye what the retinal image will be like for a given visual stimulus, and even this image does not correspond to the subjective report. A subject may say that he sees two separate lines on a dark ground although his retina is really being illuminated by two bands of light which have overlapping bell-shaped intensity distributions; in other words there may be quite a lot of light falling on the retina between the two lines, where the subject reports dark ground.

Other examples from the fields of hearing, colour, and taste will be given later; in each one there is a discrepancy between what the subject reports and what we can infer about the activity at his receptor surface. Presumably the signals from the receptors undergo transformation as they advance along the sensory pathways. If we could discover the neural mechanism that accomplishes this transformation, it might tell us a great deal about neural transmission in general, because the cells of the sensory pathways do not differ in any obvious way from those in other parts of the nervous system.

It might be well at this point to admit that we are being naïve in assuming that what a subject says he perceives is any indication of what is going on in his nervous system. In this paper, instead of embarking on a distracting and inconclusive discussion of the nature of phenomenal awareness, we shall persevere in this naïveté. When a subject reports that he sees a green light, or hears a high-pitched note, or tastes salt, we shall assume that it indicates that particular groups of "sensory" neurons are firing. For the sake of brevity, but with no other justification, such relatively elementary perceptions will often be referred to as sensations.

[1] Paper read at the Annual Meeting of the Canadian Psychological Association, Toronto, June, 1957.

[2] The author gratefully acknowledges support from the Ford Foundation and the National Research Council during preparation of this paper.

Problems of Visual Acuity and Pitch Discrimination

An early attempt to explain the discrepancy between a receptor excitation pattern and the resulting sensation was made by Marshall and Talbot (10). Their interest lay mainly in the visual system. Among other apparent paradoxes mentioned in their paper is the fact that one can detect a vernier offset of a hair line corresponding to only about 1/30 of the width of a foveal cone; it may be inferred from this that the perception of a near-threshold displacement of a visual stimulus cannot involve a simple switch of excitation to adjacent receptors. It could, however, involve a change in the locus of firing in the visual cortex, because the "grain" there is about a hundred times finer than in the retina. This is due to the branching and multiplication of fibres along the route and, in theory, a threshold displacement of the retinal image could shut off (or turn on) two or three rows of cortical cells. The problem is to discover how the pattern of neural activity at the cortex could become so sharp in spite of the branching and overlapping of the afferent pathways.

Marshall and Talbot's solution is complicated and not very satisfactory. Moreover, it involves principles such as physiological nystagmus which make it inapplicable to other sense modalities where the need for sharpening is equally great. What I consider to be a mechanism of more general application will be presented shortly.

With regard to the problem of pitch discrimination, Békésy (3) has made some excellent measurements of the vibrations of the basilar membrane, demonstrating that a considerable length of it vibrates when a pure tone of any frequency is presented to the ear (see 3, Fig. 32). If we assume that the hair cells of the organ of Corti fire at a rate determined by the displacement of the corresponding point on the basilar membrane, we can see that a loud tone of, say, 100 cycles might fire the hair cells at the point which is nominally tuned to 800 cycles as vigorously as a quiet tone of 800 cycles would. It is clear that if different cortical neurons are to fire for each discriminable tone the pattern of output from the hair cells must be drastically sharpened along the route. The same thing is true for the sensation of touch; the two-point threshold is less than would be expected from the separation between endings of single nerve fibres.

Discrimination of Colours and Tastes

Leaving spatial acuity for a moment, let us turn to discriminations of quality, particularly colour and taste. In discussing colour vision it is convenient to recognize four primary central processes representing red, yellow, green, and blue. At the periphery, on the other hand, the evidence

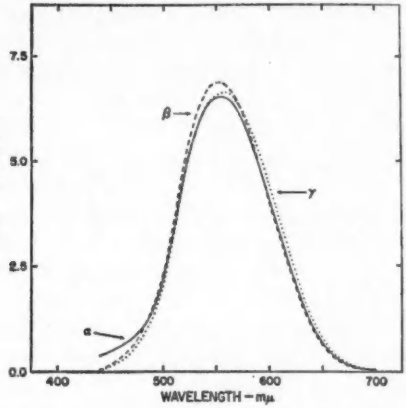

FIGURE 1. Spectral sensitivity curves for the receptors in an opponent-colours theory, reproduced from Hurvich and Jameson (7).

as to the number of types of colour receptor is equivocal. Since in theory no more than three types are required, and a larger number might well be wasteful of optic nerve fibres, the three-receptor hypothesis will be accepted for the purpose of discussion.

According to Hecht's calculations (6) the spectral sensitivity curves for the three receptors overlap to such an extent that they can scarcely be distinguished. Figure 1 is a curve of spectral sensitivities derived in the same way as Hecht's curves, but from more recent data, by Hurvich and Jameson (7, 8). As may be seen, when green light (wavelength 530 millimicra) is falling on the retina, it fires the blue and red receptors (α and γ) nearly as strongly as the green receptors (β), though only the latter are producing a chromatic sensation. It thus appears that the colour pathways must incorporate a sharpening device analogous to that of the spatial systems.

Finally an example from the realm of taste. Pfaffman (12) has made a number of measurements of the activity of fibres in the nerve from the taste receptors of the tongue. One typical experiment showed two fibres, each sensitive to both sucrose and sodium chloride, but with different relative sensitivities. One was more sensitive to saline than to sucrose, the other more sensitive to sucrose than to saline. In reference to his results Pfaffman says "the present evidence further indicates that the degree of specificity may be broad for some elements and narrow for others. The results of the single fibre analysis are not consistent with the classical view that taste sensitivity is compounded of four primary taste modalities. . . .

The afferent nerve activity in taste is best described as a pattern of differences in the relative activity of different fibres" (12, p. 438). Here again the sensation seems to be different, more sharply defined than the activity at the periphery.

A Neural Hypothesis

I shall now present a neural mechanism that will, I believe, explain the progressive sharpening or sorting of qualities in the examples mentioned. The mechanism conforms well with what we know about the anatomy and physiology of the pathways concerned. As suggested earlier, its explanatory value is not confined to the sensory pathways; a similar mechanism, applied to diffuse instead of point to point connections, forms the basis of the writer's theory of the cell assembly (11).

To simplify matters let us confine the preliminary discussion to two fibres similar to those of the Pfaffman experiment on taste mentioned above. The upper histogram at the left of Figure 2 shows the activity of two receptors, *a* and *b*; those below show the activity at two synaptic relay

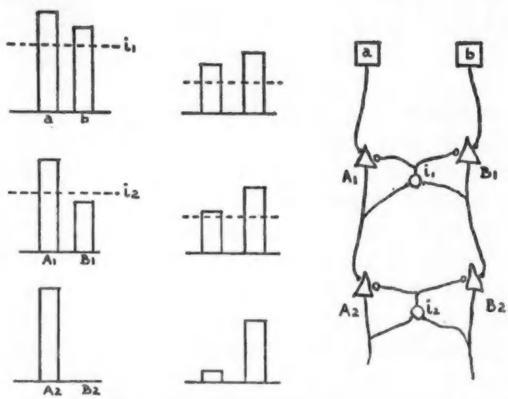

FIGURE 2. (*Right*) Circuit showing two receptors *a* and *b* and the first and second order neurons of the pathway to the cortex. (*Left, top to bottom*) Histograms of the excitation from receptors *a* and *b* falling on the cells A_1 and B_1; excitation from the cells A_1 and B_1 falling on the cells A_2 and B_2; and the activity of cells A_2 and B_2. The histograms in the middle of the figure show the activities of the same structures when a weaker, less discriminable, stimulus which favours the *b* receptor is applied.

points on the way to the cortex. They illustrate the situation in which receptor *a* is more strongly stimulated than receptor *b*; the histograms to the right show what might happen with a weaker and less clearly differentiated stimulus which slightly favours the *b* receptor. The dotted lines cutting the histograms represent thresholds above which the frequency of incident excitation must rise before the next stage (e.g., cells A_1 and B_1) will fire; moreover, the rates at which A_1 and B_1 then respond are roughly proportional to the excess of afferent excitation above the dotted line. The resulting output is reproduced in the next lower histogram, which of course also represents the excitation reaching the second order neurons A_2 and B_2.

The eventual effect of the "clipping" and amplification, repeated in a number of stages, is to accentuate any differences there might be in the original input to the two channels. In the left-hand example of Figure 2 the activity is completely suppressed in the weaker channel after the second stage. Thus quite small changes in the relative excitation of two receptors can lead to a switching of activity from one cortical neuron to another.

We still have to explain the cut-off point of each stage, represented in the diagram by a dotted line. If it were maintained at a fixed level, we should merely gain selectivity at the expense of sensitivity. Small signals would be blocked and nothing more. We must provide a mechanism which will adjust the cut-off point so that the stage discriminates against the weaker signal whatever the absolute intensity of firing may be. One way of achieving this would be to use the average output of the two cells to determine the cut-off point, and this might be done by a neuronal circuit similar to that shown on the right of Figure 2. Collaterals of the axons of the primary neurons A_1 and B_1 deliver impulses into a common inhibitory pool (shown in the diagram by the single inhibitory neuron i_1) which feeds back equally to the two cells and counteracts the excitation they are getting from the receptors. In this way the threshold of the cells is made to depend on the total output of the stage, and for the simple two-channel case the cell getting the smaller input will be relatively more affected by the inhibition than the other. Clearly both cells cannot be completely inhibited at once, or the inhibitory neuron would cut off its own source of excitation, but one of the cells might suffer that fate if it received much less excitation than the other, as is illustrated in the next stage of the diagram (Figure 2). When the input to the receptors is small the inhibition falls and the sensitivity of the system goes up; but with very weak stimuli the inhibition may become so sporadic that the acuity is seriously diminished.

The Schema Applied to Colour Vision

The two-quality sensory system described above probably has no counterpart in the nervous system, but the principle can be extended to the more complex systems required for taste, smell, and vision. The detailed problems of colour vision are appallingly complicated, but one point seems relatively clear: somewhere in the system there are four processes (not counting black and white) arranged in mutually opposed pairs. One opposed pair represents the primary colours blue and yellow, the other represents red and green. As we saw earlier, this does not mean that there must be four types of colour receptor in the retina. If there were three (the alpha, beta, and gamma receptors of Figure 1) with overlapping spectral sensitivities, their outputs could be connected in mutually inhibiting pairs of pathways like those of the circuit in Figure 2. Then, when alpha receptors were more intensely excited by the light than beta receptors, the activity would be transmitted only to "blue" central neurons, and when they were less excited than beta receptors the activity would be diverted instead to the "yellow" central neurons. A similar arrangement between receptors of the beta and gamma types would give rise to either "red" or "green" central activity.

The picture is of course oversimplified; instead of the alpha and gamma receptors being balanced separately against the beta receptors it is more likely that they are balanced against a combination of the output of all three types, converging on a single optic nerve cell. The fibre of this cell would then transmit black-white information, and only two other fibres would be needed to convey complete information about colour and brightness at the corresponding point on the retina. The other two fibres would be one "blue-yellow," fed by the alpha receptor, and one "red-green", fed by the gamma receptor. In the lateral geniculate or visual cortex the colours would be sorted out by circuits like that of Figure 2.

A branch of the "black-white" or brightness fibre would be balanced against the "yellow-blue" fibre so that an excess of activity in the latter would fire "blue"' sensory neurons; alternatively an excess of activity in the branch of the brightness fibre would fire "yellow" sensory neurons. Another collateral of the brightness fibre would be similarly balanced against the "red-green" fibre to regulate the firing of "red" and "green" sensory cells. The resulting theory is similar to the Hering four-colour theory except that the opposing colour processes are regarded as occurring centrally, not in the receptors as Hering postulated.

The Schema Applied to Acuity

Turning now to the problem of "spatial" acuity in the visual and auditory systems, we find that the mechanism of Figure 2 will again

perform the required function. Take first the case where a change of a fraction of a cone width in the position of a retinal image produces a sensory change. It is clear that the only effect that the displacement can have at the receptor level is to change the relative firing rates of two or more adjacent cones. We may therefore regard these as the counterparts of the receptors *a* and *b* of Figure 2. As we have seen, a slight shift in the ratio of firing of these two receptors could shift the activity completely from one cell to another at the cortical end of the system. As a matter of fact the sharpest edge that can be focussed on the retina spreads over several cones (because of diffraction) so that a threshold change of position will cause a change in the ratios of firing among a number of retinal elements.

The circuit of Figure 2 leaves out of account the fact that there is lateral overlap and multiplication of pathways at successive stages on the way to the cortex, resulting in a much finer grain at the cortex than at the retina. The phenomena of overlap and multiplication are well established, both by the histological studies of Polyak (13) and others, and by the fact of areal summation of sub-threshold stimuli in the retina (2). Paradoxically, this lateral diffusion of excitation is actually necessary for improving the acuity in a system with multiplying pathways, but it must be accompanied by an inhibitory process whose lateral spread is even greater than that of the excitation. The postulated connections of such a system are shown in Figure 3; as a result of the overlap, afferent activity from a number of receptors produces a bell-shaped distribution of excitation on the layer of primary neurons, and the inhibitory process then cuts off the edges. As before, the inhibitory firing is determined by the average efferent activity of the region so that it can cut near to the peak of excitation, but under steady conditions cannot go above it. In this way the ridge of activity may be kept only a few cells wide all the way up to the cortex in spite of the extensive branching of the fibres.

There is a good deal of evidence in support of the double facilitatory-inhibitory effect at the relay points of the visual system. One clear example is contained in a paper by Kuffler (9). He illuminated the retina of a cat with two microscopic spots of light, at the same time recording the activity of a single cell at the third stage of the visual pathway. After having found the point on the retina which gave a maximum response from the cell to one of the light spots, he found that switching the second spot onto a point on the retina a fraction of a millimeter away from the first would either reduce or completely cut off the activity of the cell. This suggests that the spread of inhibition from the second point was more effective than the spread of excitation, at the levels of illumination used. Further evidence for the widely distributed inhibitory effect in

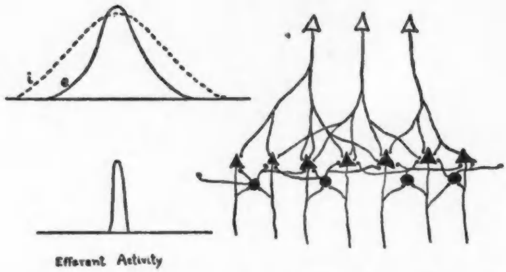

FIGURE 3. (*Right*) Circuit showing the connections from three receptors to the primary neurons in a system with multiplying pathways. The round cells below the primary neurons are inhibitory. There is lateral spread and overlap of both the afferent and the inhibitory connections to the primary neurons. (*Left*) A smoothed curve of the distribution of excitation (e) of primary neurons when a point on the receptor surface is stimulated, and the distribution of inhibition (i) on the same neurons resulting from the firing of inhibitory cells by the efferent activity. Only the cells that are receiving more excitation than inhibition are fired, resulting in the distribution of efferent activity shown in the lower curve.

the retina is provided by the subjective change of brightness in one area produced by an objective change of brightness in an adjacent part of the field, as described and measured by Diamond (4).

Finally, the mechanism of pitch discrimination must be mentioned. By now the principle should be familiar: whenever a cell is a little more active than its neighbours on either side, it will inhibit them more than they can inhibit it. This explains why the loud 100-cycle note mentioned earlier cannot fire a wide band of cortical cells even though it may fire hair cells over a considerable length of the organ of Corti. The lateral spread of inhibition is such that only the excitation coming from the hair cells near the peak of the vibration of the basilar membrane is transmitted to the cortex; all weaker activity is blocked. The louder the note, the further along the organ of Corti the hair cells will be fired, but at the same time the inhibitory activity generated at the peak will be stronger, so that it will be able to block the additional cells. A second note at a sufficient frequency interval from the first will produce a second peak of vibration in the basilar membrane which may raise the hair cell activity above the inhibitory level at that point; but for weak sounds, or those whose frequency is too close to that of the louder note, masking will still be evident.

An experiment by Galambos (5), in which a cell in the second or third stage of the auditory pathway was inhibited by masking tones differing in frequency from the one that was firing the cell, is exactly analogous to Kuffler's experiment with the two spots of light mentioned above. The results are further evidence for the mechanism suggested in this paper.

Allanson and Whitfield (1) in a recent paper represent the cochlear nucleus (the first relay nucleus of the auditory pathway) by a diagram somewhat similar to the circuit of Figure 2, though their conception of how the circuit functions is different from that proposed here. It is interesting that they arrived at their diagram more on the basis of the anatomy of the nucleus, and from measurements of the activity of single efferent fibres, than from behavioural considerations.

Summary

The present paper has described a neural transmission system capable of transforming the rather "fuzzy" activity at the receptor surfaces into the sharply defined activity which corresponds to sensations. A single tone, or a small spot of light, produces a widespread disturbance in the sensory pathway concerned. We have no immediate awareness of the extent of the spread, however, and it only affects our perception when neighbouring stimuli excite common elements in a pathway and so interfere with one another. We may then be surprised, as the Gestalt psychologists were, at the apparent interaction of stimuli across empty space. But of course the space is only empty at the central end of the pathway. Many optical illusions are probably caused by such interaction in the peripheral parts of the visual system.

The qualities of sensation are no better defined at the periphery than are its spatial attributes. Colour, taste, smell, temperature, and so on do not result from the excitation of unique receptor types, one for each quality. Usually the responses of the receptors do not change sharply as the quality of the stimulus changes; it is the *ratio* between the activities of receptors that varies, and it is this ratio that determines the central firing. As we have seen, the transformation from a *ratio* of firing to a *pattern* of firing can be accomplished by the same neural circuit as that postulated to account for spatial acuity.

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EFFECTS OF ENRICHED AND RESTRICTED EARLY ENVIRONMENTS ON THE LEARNING ABILITY OF BRIGHT AND DULL RATS[1]

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SEVERAL RECENT SURVEYS of the literature (2, 3, 4, 9) reflect the increased emphasis being placed upon study of the relationship between early environment and later behaviour in animals. Learning ability has received particular attention, and several studies have shown that the learning ability of adult animals is affected by the quality of their infant environment. More specifically, they indicate that animals raised in "enriched" or "stimulating" environments are superior in adult learning ability to animals raised in "restricted" or "unstimulating" environments.

These results were obtained with animals possessing a *normal* heritage of learning ability; hence there remains the possibility of differential effects for animals of superior or inferior endowment. The present study was designed to explore this possibility. Its specific object was to test for possible differential effects of enriched and restristed early environments on the problem-solving ability of bright and of dull rats.

METHOD

Subjects

Forty-three rats of the McGill bright and dull strains (F_{13}) served as subjects. They were divided into 4 experimental groups: a bright-enriched group containing 12 rats (6 males, 6 females); a dull-enriched group containing 9 rats (4 males, 5 females); a bright-restricted group containing 13 rats (6 males, 7 females); and a dull-restricted group containing 9 rats (4 males, 5 females). Normally reared rats served as controls.

Environments

The 4 groups of experimental animals were placed in 4 cages which occupied a grey painted room 12′ × 6′ × 8′. At one end of the room a window allowed diffuse light to pass through. A large rectangular partition, suspended from the ceiling, divided the room lengthways. The two restricted cages were placed on one side of the partition, the two enriched cages on the other side. The side of the partition facing the restricted cages was grey, matching the colour of the room. The side of the

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partition facing the enriched cages was white with "modernistic" designs painted upon it in black and luminous paint. The partition was so placed that animals in the restricted environment were unable to see the enriched cages.

The 4 cages, each measuring 40" × 25" × 13", were covered with ⅛-inch wire mesh. Each of the enriched cages contained the following objects: ramps, mirrors, swings, polished balls, marbles, barriers, slides, tunnels, bells, teeter-totters, and springboards, in addition to food boxes and water pans. Some of the objects were painted black and white, and all were constructed so that they could easily be shifted to new positions in the cage. The restricted cages were identical with the enriched ones in size and mesh coverings, but contained only a food box and a water pan.

Test Apparatus

The 12 problems of the Hebb-Williams closed field maze were administered in the manner described by Rabinovitch and Rosvold (8).

Procedure

The 4 groups of animals were kept in their respective environments from the time of weaning at 25 days of age until the age of 65 days, when testing on the Hebb-Williams maze was begun. They were also kept there throughout the testing period.

Since one of the restricted and one of the enriched cages received more light than the others did from the window, the animals were shifted every three days to equate for this difference. In addition, the objects in each of the enriched cages were moved about at random every three or four days. During these moving periods and while the cages were being cleaned all animals were given the same amount of handling.

Results

For purposes of statistical analysis and interpretation of the data the performances of the enriched and restricted animals were compared with the performances of 11 bright and 11 dull animals raised in a "normal" laboratory environment. These were the animals that formed two control groups in an experiment by Hughes and Zubek (6).

Effect of the Enriched Environment

In Table I are recorded the mean error scores for the bright-enriched group, the dull-enriched group, and the bright and dull animals raised in a normal environment. It can be seen that the average number of errors

TABLE I

Mean Error Scores for Bright and Dull Animals Reared in Enriched and Normal Environments

	Enriched environment	Normal environment
Bright	111.2	117.0
Dull	119.7	164.0

made by the bright animals in the enriched environment is only slightly below that of the bright animals raised under normal conditions (111.2 *vs.* 117.0). This difference is not statistically significant ($t = 0.715$, $p > .4$). On the other hand, the error scores of the dull animals raised in an enriched environment are considerably below those of dull animals reared in a normal environment (119.7 *vs.* 164.0). This difference of 44.3 errors is significant ($t = 2.52$, $p > .02 < .05$). The results indicate, therefore, that an enriched early environment can improve considerably the learning ability of dull animals, while having little or no effect on that of bright animals.

Effect of the Restricted Environment

Table II shows the mean error scores of the bright-restricted group, the dull-restricted group, and the bright and dull animals raised in a normal environment. It is seen that the bright-restricted group made many more errors than the normally raised bright animals. The difference of 52.7 errors is statistically significant ($t = 4.06$, $p < .001$). On the other hand there is no significant difference between the dull-restricted group and the normally raised dull animals ($t = 0.280$, $p > .7$). Thus the dull animals were not affected by their restricted early experience while the bright animals were significantly impaired in learning ability.

Comparative Effects of Enriched and Restricted Environments

Tables I and II also indicate the degree of improvement produced in the dull animals by their period of enriched experience, and the degree of retardation which the bright animals suffered because of their impoverished experience. Although the dull-enriched group averaged 8.5 more errors than did the bright-enriched, this difference is not significant ($t = .819$, $p > .5$). In other words, after undergoing a period of enriched experience the dull animals became equal in learning ability to the bright animals. The difference between the bright- and dull-restricted groups in Table II is also obviously insignificant; thus, the bright animals, after a period of early impoverished experience, showed no better learning ability than did the dull animals.

TABLE II

MEAN ERROR SCORES FOR BRIGHT AND DULL ANIMALS REARED IN RESTRICTED AND NORMAL ENVIRONMENTS

	Restricted environment	Normal environment
Bright	169.7	117.0
Dull	169.5	164.0

Discussion

The results clearly show that both enriched and restricted early environments have differential effects on the learning abilities of bright and of dull rats. A period of early enriched experience produces little or no improvement in the learning ability of bright animals, whereas dull animals are so benefited by it that they become equal to bright animals. On the other hand, dull animals raised in a restricted environment suffer no deleterious effects, while bright animals are retarded to the level of the dulls in learning ability.

Although it had been anticipated that the two extremes of environment would have differential effects on the bright and dull animals, the bright-enriched animals were still expected to perform better than the dull-enriched animals. Bright animals, with their presumably better cerebral functioning, would be expected to make better use of the extra experience afforded by an enriched environment than would dull animals, with their presumably inferior cerebral functioning. The bright-enriched group did in fact make fewer errors, and the difference, though not statistically significant, suggests the possibility of a real difference in learning ability which the twelve problems of the Hebb-Williams test failed to reveal. The ceiling of the test may have been too low to differentiate the animals, that is, the problems may not have been sufficiently difficult to tax the ability of the bright rats. This has happened with tests of human intelligence such as the Stanford-Binet (**1**), on which adults of varying ability may achieve similar I.Q. scores although more difficult tests reveal clear differences between them. It might also be suggested that it is relatively more difficult for the bright animals to reduce their error scores, say from 120 to 100, than for the dull animals to reduce theirs from 160 to 140.

In spite of these possible qualifications of the present results for the enriched environment, it seems reasonable to accept them pending future experimentation.

The effects of the restricted environment are not so difficult to accept. Under such conditions the bright animals, even with their superior learning capacity, would be expected to show an inferior performance. Learning is a function of experience as well as of capacity, and hence, under conditions that severely limit experience, the superior capacity of the bright animals is never fully utilized and they perform far below their potential level. On the other hand, not much decrement would be expected in the dull animals, since they are already functioning at a low level of intellectual capacity.

What physiological mechanism or mechanisms underlie these changes in learning ability? Several theories have attempted to explain the rela-

tionship between sensory stimulation and learning behaviour, perhaps the most systematic being that of Hebb (5). Hebb has suggested that neural patterns or "cell assemblies," which he regards as the physiological basis of learned behaviour, are built up over a period of time through varied stimulation coming through specific sensory pathways. This stimulation is especially effective if it occurs during infancy. Others (7, 9) also believe that varied stimulation coming through non-specific projection pathways (e.g., the thalamic-reticular system) aids in the learning process by keeping the brain in an alert state. Thus at the neurophysiological level varied stimulation seems to play a dual role in the learning process; it may act directly on cerebral cells to form cell assemblies, and may also aid learning by keeping the brain "primed" or alert.

If, then, varied stimulation has such an important role in establishing the physiological components (e.g., cell assemblies) underlying learned behaviour, it seems reasonable to assume that a certain level of varied stimulation is necessary if learning (i.e., establishment of cell assemblies) is to occur with maximum efficiency. It may also be assumed that the initial difference in learning ability between the bright and dull rats in some way reflects an underlying neurophysiological difference in their capacity to "utilize" such stimulation. On the basis of these assumptions the present findings might be explained as follows.

In a *normal* environment the level of stimulation is sufficient to permit the building up of cell assemblies (or some other neurophysiological unit underlying learned behaviour) in the superior brains of the bright animals. It is not sufficient, however, to permit them to be readily built up in the inferior brains of the dull animals. In a *restricted* environment the level of stimulation is so low that it is inadequate for the building up of cell assemblies even with the superior cerebral apparatus of the bright rats, who therefore show a retardation in learning ability. The dulls, however, are not retarded further, since the level of stimulation provided by the normal environment was already below their threshold for the establishment of cell assemblies. In the *enriched* environment the level of stimulation is above the higher threshold of the dull animals, who consequently show improvement in learning ability. The brights show little or no improvement because the extra stimulation is largely superfluous, that provided by a normal environment being adequate for the building up of cell assemblies.

Such an interpretation is open to several criticisms. For instance, the assumption that bright and dull rats differ in their inherited capacity to utilize stimulation is open to question. Furthermore, as pointed out above, possible inadequacies of the Hebb-Williams test may throw doubt on the findings for the bright-enriched rats. Nonetheless, although this theoreti-

cal interpretation obviously needs a more adequate foundation, it seems best fitted to account for the experimental data in the light of present neurophysiological knowledge.

Summary

Forty-three rats of the McGill bright and dull strains were used as experimental subjects in an investigation of possible differential effects of enriched and restricted early environments on learning ability.

At 25 days of age, 12 bright rats and 9 dull rats were placed in enriched environments, and 13 brights and 9 dulls were placed in restricted environments. At 65 days of age all animals were introduced to the training and testing procedures of the Hebb-Williams maze, their performances being compared with those of normally reared bright and dull controls.

The bright animals reared in enriched environments showed no improvement in learning ability over bright controls reared under normal laboratory conditions. The dull animals, on the other hand, benefited greatly from the enriched experience and attained a level of performance equal to that of the bright animals. Rearing in restricted environments had converse effects. The dull animals suffered no impairment as compared with dull controls, while the bright animals were retarded to the level of the dulls in learning performance.

Possible neurophysiological explanations are suggested.

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THE EFFECTS OF EARLY GENTLING AND SHOCK ON GROWTH AND BEHAVIOUR IN RATS[1]

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IT HAS been reported that gentling rats during the three weeks after weaning results in faster rate of growth, higher rate of metabolism, decreased emotionality, and greater resistance to stress. Agreement is lacking, however, since some researchers have failed to obtain these effects. Thus, while Weininger (11) and Ruegemar and Silverman (8) found a large increase in weight, and Mogenson, McMurray, and Jaques (7) a small increase, Scott (9) found no change. Two of these experiments also included behavioural measures with discrepant results: Weininger reported that gentled animals were more active and less emotional, but Scott reported no differences.

There is also lack of agreement on the effects of early traumatic experience on behaviour. Hall and Whiteman (4) reported that exposing mice to intense stimulation during infancy resulted in "emotional instability" later in life, while Griffiths and Stringer (3), using rats, found that there were no changes.

In view of these inconsistent reports, further experimentation seemed warranted. The present study deals with growth and behavioural changes in relation to gentling and electric shock during 21 days after weaning.

PROCEDURE

Twenty-seven male hooded rats of the Royal Victoria Hospital stock, matched according to weight were divided into three groups of nine, and given the following treatment from 24–45 days of age: Group 1, gentled 10 minutes daily; Group 2, control, not handled or shocked; Group 3, electric shocks administered to the feet. All animals were tested in an open field situation on days 46–48, and again on days 94–96.

During the first part of the experiment (days 24–49) all animals were housed in a box with 9 compartments, 3 to a compartment. The compartments were 10" × 7" × 21" in size, with a grid floor. Food (Purina Fox Chow) and water were available at all times. After the period of gentling and shocking and the first open field testing, all 27 animals were housed in a large community cage. After the initial weighing, they were weighed at intervals of 10 days to 2 weeks.

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Gentling consisted of placing the weanling rat in the fold of one arm and stroking lightly along the head and back with the free hand. A light cloth was placed over the front part of the animal's body to prevent additional visual experience.

The shocked group received electric shocks to the feet delivered from the standard 110-volt AC source, reduced by means of a variable voltage regulator. Each time these rats were shocked, the voltage was increased until they gave evidence that they were in considerable discomfort; at the age of 24 days the maximum voltage was 35, but by 45 days the animals were given shocks up to 88 volts. An average of 5 shocks daily of 3 to 5 seconds duration was given at random.

On days 46–48 (and again on days 94–96) Ss were placed individually in an open field for 5 minutes daily. The field was 4 feet square and surrounded by a wall 12 inches high. The floor was of white oil-cloth marked off into 25 nine-inch squares and was illuminated by a 100-watt bulb 4 feet above the floor.

At the beginning of the 5-minute test, S was placed in one corner of the field. Records were taken of (*a*) rearings. (*b*) groomings, (*c*) number of squares entered, (*d*) defecations, and (*e*) urinations. At the age of 50 days (and again at 97 days) Ss were tested in a "curiosity box" following the procedure of Berlyne (1). The duration of contact by S with each of the 3 objects encountered in the box was recorded and these durations were combined. Total time spent investigating all 3 objects was used as the datum for statistical analysis.

At the age of 113 days the animals were placed in a Skinner box in a dimly lighted room for 30 minutes, and the rate of spontaneous bar-pressing was recorded for 5-minute intervals.

Results

Weight Gain

As shown in Table I, the gentled animals did not gain more weight than the controls. This is consistent with Scott's results (**9**) but contrary to a number of other reports (**6, 7, 8, 11, 12**), In fact, the gentled animals were somewhat lighter; the difference was not significant but appeared consistently at all ages.

Early traumatic experience, however, markedly influenced weight gain. The animals exposed to electric shocks were significantly lighter than the control or gentled groups (day 45: $p < .001$; day 69: $p < .02$; day 91: $p < .05$). The weight difference was greatest at the end of the

TABLE I

Mean Weights in Grams of Gentled, Control, and Shock Groups at Weaning and after Treatment

Treatment groups (each $N=9$)	Age of rats in days 23	45	56	69	91
Gentled	37.5	137.2	188.9	233.8	279.0
Control	38.2	146.3	197.5	241.0	285.3
Shocked	38.8	120.6	171.5	219.4	268.5

21-day shocking period and became steadily less thereafter. The general behaviour of the shocked animals gave clear indication that the shocking was a severe stress; they reacted violently by squealing, jumping about, attempting to climb the walls, often attacking one another, and occasionally rolling over on their backs in apparent attempts to avoid the shock. However, during the intervals between the shocks, the behaviour of the traumatized group did not differ markedly from that of the control animals.

Behaviour

There were no significant differences between the groups for any of the measures used in the open field at 47 days (Table II), although the gentled group was slightly more active as judged by number of squares

TABLE II

OPEN FIELD BEHAVIOUR (GROUP MEANS) OF GENTLED, CONTROL, AND SHOCKED GROUPS IN TWO 5-MINUTE TESTS

Groups	Squares entered	Rearings	Groomings	Defecations
		(Age: 46-48 days)		
Gentled	109.3	92.2	13.2	7.7
Control	98.1	77.1	11.1	8.8
Shocked	106.9	76.8	15.2	4.1
		(Age: 94-96 days)		
Gentled	124.6*	57.9	12.3	2.9
Control	73.0	41.1	11.2	3.3
Shocked	77.4	38.6	14.2	0.0

*Gentled *vs.* Controls: $t = 2.06$, $p = .07$. Gentled *vs.* Controls and Shocked combined: $t = 2.26$, $p = .04$.

entered and rearings. Defecations for the shocked group at 46–48 days were fewer than those for the non-shocked animals, but the difference did not reach statistical significance.

During the second testing, however, defecations by the shocked animals were significantly fewer than by the non-shocked animals. No defecations were observed for the shocked animals while 8 non-shocked rats (4 gentled, 4 controls) defecated ($\chi^2 = 3.8, p = .05$).

At 94–96 days of age, the gentled subjects were more active (Table II), entering a mean total of 124.6 squares, as compared to 73.0 for the control group and 77.4 for the shocked group. Since there was no difference between shocked and control groups, their scores for this measure were combined and compared with those of the gentled animals ($t = 2.26$,

$p = .04$). The data for rearings are also in the direction of the gentled animals being more active, but the difference is not significant.

The groups did not differ in their behaviour in the Berlyne "curiosity box."

Although the groups did not differ significantly in number of presses in the Skinner box, the trend agrees with the open field results in that the gentled animals were more active. The mean numbers of spontaneous presses for the 30-minute test period were: gentled, 27.6; control, 20.7; shocked, 18.7.

Discussion

The results of this experiment have led us to inquire why increased weight gain after gentling has been observed in some experiments and not in others. The data obtained by various investigators indicate marked differences in the observed effects of gentling upon growth. Since the experimental procedures have often been quite similar, we are inclined to attribute the discrepant results to differences in the initial emotional reactivity of the animals. We assume that the effects of gentling on growth would be greater on wilder or more reactive rats than on rats initially tamer. Differences in emotional reactivity at the beginning of the experiment (at 21–24 days of age) could occur as a result of variation in several factors such as intra-uterine environment and early experience with the mother (**10**), general care provided in the animal colony, as well as strain differences.

In terms of the hypothesis proposed previously (**7**) this means that gentling would be expected to have little effect on animals whose pituitary adrenal cortical activity was already low, as is assumed for the subjects of this experiment, but in animals emotionally more reactive such treatment would reduce the adrenal response and result in faster growth. Such effects of gentling or handling would be expected only during early life when the secretion of growth hormone (STH) is greater. The effect of electric shock on weight gain in this experiment is attributed to the electric shock acting as a severe stressor and increasing pituitary adrenal cortical activity in the young animals. Growth is then retarded by the antagonistic action of the increased corticoid output on STH.

The results of a recent experiment (**5**) suggest that animals which do not benefit from special handling after weaning may show increased weight gain if given this treatment from birth to weaning. If there is really a critical period for special handling, as Levine and Otis suggest, then it may end earlier in some strains of rats (**5, 9**, this experiment) than in others (**6, 8, 10, 11**), and it may be related to the age at which the

normal fall in STH output occurs in various strains. According to this notion, in order to enhance growth, gentling would have to be done before the decline in STH occurred. Apparently Gertz (2) began the special handling too late in the life of his animals to have it produce effects on weight or behaviour.

The finding that the gentled rats were not more active in the open field at 46–48 days is inconsistent with the results of Weininger. Weininger's experimental animals had additional visual experience during gentling, and this may be related to their increased activity in the open field situation. An important observation, not anticipated by us, was the significantly greater activity of the gentled subjects in the open field at 94–96 days, when there had been no difference earlier. The basis of this phenomenon is not clear and other experiments are necessary.

The fact that our shocked animals defecated less than the non-shocked animals in the open field situation is at variance with the results of other experiments. Griffith and Stringer (3) reported no effect of trauma on any of their measures, including defecations in the open field. However, interpretation of their study is complicated by the large amount of handling and experience in other tests given before the open field, and especially by the prior administration of electric shock to all rats while being tested in the Lashley discrimination apparatus. Hall and Whiteman (4) reported that mice subjected to early traumatic experience defecated more in the open field. However, since they tested the animals in the same apparatus in which they had been traumatized, it seems likely that they were producing a conditioned emotional response. This interpretation is supported by the fact that, when tested in a different apparatus, the experimental subjects did not defecate more than the controls. The fact that our shocked animals defecated significantly less than the non-shocked may be simply explained. After being exposed to very intense stimulation during shocking, the open field situation was much less stressful for the shocked group than for the other two groups.

Summary

The effects of gentling and shock in infancy on growth and behaviour were investigated. Male hooded weanling rats served as subjects in one or other of the following groups: gentled, control, shocked. At six weeks of age, after three weeks of treatment, the gentled animals did not differ from the controls in weight, but the shocked animals were significantly lighter. In the behavioural tests the gentled animals showed more gross bodily activity and the shocked group less elimination than the controls. Some theoretical implications of these results are considered.

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EFFETS DE L'HYPOPHYSECTOMIE SUR L'APPRENTISSAGE D'UNE REACTION ECHAPPEMENT-EVITEMENT[1]

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LES TRAVAUX de Selye sur le stress ont démontré l'existence d'un mécanisme physiologique responsable de l'adaptation de l'organisme à son milieu (17). L'axe hypophyso-adrénalien constitue le rouage le plus important de cet appareil de régulation. Etant donné le rôle fondamental des glandes endocrines dans l'adaptation physiologique, on peut se demander s'il n'existe pas certains liens entre l'activité de ces glandes et les processus psychologiques d'adaptation.

Pour le psychologue, adaptation est synonyme d'apprentissage. Or ce processus a été étudié de diverses façons. Les premiers travaux réalisés dans ce domaine distinguaient deux principaux types d'apprentissage: le conditionnement classique et le conditionnement instrumental. L'une des techniques les plus utiles pour l'étude du mécanisme d'adaptation psychologique prétend combiner ces deux genres de conditionnement. Il s'agit de l'apprentissage échappement-évitement. L'intérêt soulevé par cette technique vient surtout des interprétations théoriques auxquelles elle a donné lieu. Mowrer prétend que dans une telle situation la réduction de l'anxiété joue le rôle d'agent de renforcement et que, si l'animal apprend à éviter le stimulus nocif, c'est grâce à l'anxiété déclenchée par le signal (16). Ce genre d'explication, on le voit, rejoint d'autres théories sur le rôle essentiel que joue l'anxiété au niveau humain dans les processus d'adaptation psychologique.

Selon la théorie de Mowrer l'anxiété est une variable intermédiaire dont on infère la présence ou l'absence d'après la performance de l'animal. Avec une telle interprétation de l'anxiété, on arrive facilement à prétendre démontrer l'existence d'un lien causal entre sa disparition et l'absence d'une structure anatomique ou d'un mécanisme physiologique quelconque. C'est ainsi qu'Applezweig et Baudry (1) utilisent une situation expérimentale semblable à celle de Mowrer pour étudier l'effet des secrétions des glandes endocrines sur l'anxiété. L'hypothèse sur laquelle

[1]Cette recherche a été subventionnée par le Conseil National de Recherches du Canada. L'auteur désire aussi remercier le Dr. Hans Selye, directeur de l'Institut de Médecine et de Chirurgie Expérimentales de l'Université de Montréal, pour ses précieux conseils et pour lui avoir si gracieusement prêté ses laboratoires.

[2]Cette recherche a aussi été rendue possible grâce au travail consciencieux de MM. Jean Lavery et Joseph Kaleff, assistants de recherche.

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s'appuie leur recherche pourrait se résumer de la façon suivante: si l'apprentissage échappement-évitement est dû à un effet de réduction de l'anxiété et si l'anxiété correspond à la réaction d'alarme provoquée par l'action de l'hypophyse sur la glande adrénale, il est logique de supposer que les animaux hypophysectomisés ne peuvent apprendre à éviter un stimulus nocif dans une situation échappement-évitement.

Les résultats rapportés par ces auteurs ne rencontrent pas leurs prédictions. A cause de l'intérêt suscité par cette recherche en vue de l'interprétation des effets de l'hypophysectomie sur les processus psychologiques d'adaptation et dans le but de chercher une explication plus nette des différences entre rats normaux et hypophysectomisés, il a été jugé nécessaire de répéter l'expérience en en modifiant les conditions. L'hypothèse à vérifier est la suivante: l'hypophysectomie n'ayant pas pour effet de diminuer la capacité d'apprentissage, les différences de performance observables dans une situation échappement-évitement ne sont attribuables qu'à une augmentation du temps de réaction chez les rats hypophysectomisés.

Méthode

Tous les rats utilisés dans cette expérience étaient des femelles albinos provenant d'une même stock (Sprague-Dawley). Le groupe témoin était constitué de huit rats normaux et le groupe expérimental de sept rats hypophysectomisés. Pour enlever l'hypophyse, on pratique une légère incision sous la gorge de l'animal et, en passant à gauche de la trachée, on perfore l'os sphénoïde jusqu'à la selle turcique. L'hypophyse est alors prélevée par succion et la plaie refermée. L'opération ne dure qu'une ou deux minutes et l'animal reprend conscience presque immédiatement. L'expérimentation sur les rats de ce groupe fut retardée jusqu'à ce qu'on ait été sûr du succès de l'opération: disparition complète des effets du choc opératoire, absence d'infection, et apparition des symptômes dûs à la déficience de STH.

L'appareil utilisé est une modification de la boîte de Miller (15). Il s'agit essentiellement de deux compartiments séparés par une cloison mitoyenne. Pour faciliter l'observation des animaux, la paroi frontale de la boîte est faite de verre dépoli. Le plancher de chacun des compartiments consiste dans un grillage. Une source de courant est reliée au grillage du compartiment dans lequel l'animal est introduit de sorte que, à l'aide d'un commutateur, on peut lui donner un choc électrique. Dans la cloison qui sépare les deux compartiments se trouve une petite porte que l'animal peut ouvrir en pressant sur une clenche située juste au dessus de celle-ci.

On place l'animal dans l'appareil et, après une période qui varie entre 30 et 60 secondes, on fait résonner un vibrateur pendant 11 secondes: c'est le stimulus conditionnel (SC). Dix secondes après le début de ce stimulus, le courant passe dans la grille donnant ainsi un choc qui peut durer jusqu'à 10 secondes: c'est le stimulus non-conditionnel (SNC). Dès que l'animal ouvre la porte et passe dans l'autre compartiment, on arrête la stimulation en cours.

Au début, l'animal saute et crie dès qu'il commence à ressentir le choc et ce n'est que par hasard qu'il déclenchera la mécanisme de la porte. Si l'animal ne réussit pas à changer de compartiment, on enregistre une réponse nulle, on attend 60 secondes

après la fin du choc et on donne le stimulus conditionnel de l'essai suivant. S'il traverse avant la fin du SNC, c'est une réponse d'échappement. Enfin s'il traverse après le début du SC, mais avant le SNC, c'est une réponse d'évitement. Chaque fois que l'animal réussit à changer de compartiment, on le retire de l'appareil, on le place dans une cage pour une période de 60 secondes de repos, puis on l'introduit à nouveau dans l'appareil pour l'essai suivant. Chaque animal fait une série de 10 essais par jour. On considère qu'il a atteint le critère d'apprentissage s'il donne 10 réponses d'évitement dans la même journée. L'expérience se poursuit sur une période de 12 journées consécutives.

Etant donné la nature de la réponse instrumentale, le contrôle du poids des rats devient très important. En effet, un animal plus lourd aura plus de facilité à déclencher le mécanisme de la porte. Comme on le sait, l'hypophysectomie abolit la secrétion de STH et cause ainsi un arrêt de la croissance. Le groupe expérimental conserve donc à peu près toujours le même poids, chaque rat ne perdant que quelques grammes du début à la fin de l'expérience. Les rats normaux, au contraire, croissent régulièrement durant toute la durée de l'expérience. Afin que la moyenne générale du poids des rats normaux au cours de toute l'expérience soit à peu près la même que celle des rats hypophysectomisés, on a commencé l'expérimentation avec les rats normaux avant de pratiquer l'hypophysectomie des rats du groupe expérimental. Par conséquent, au début de la période d'apprentissage, les rats normaux étaient âgés de 42 jours et les rats hypophysectomisés de 73 jours.

Résultats

Tous les rats normaux ont atteint le critère d'apprentissage. La moyenne du nombre d'essais requis est de 47.5, la dispersion allant de 30 à 80. Cinq des sept rats du groupe expérimental ont aussi atteint le critère. La moyenne des essais requis par ces cinq animaux est de 58 et la dispersion va de 40 à 90. Deux rats du groupe expérimental n'ont donc pas réussi à atteindre le critère. Il faut noter toutefois que ces rats semblent avoir réellement appris puisqu'ils donnent très tôt de 8 à 9 réponses d'évitement par séance et que, dans les cas où ils n'ont pas réussi à traverser avant l'apparition du SNC, ils font quand même plusieurs tentatives (sauts vers la clenche) pendant les 10 premières secondes de présentation du SC. Ces deux animaux sont les plus légers du groupe, ce qui peut expliquer logiquement leur échec.[3]

Si l'on se base sur le pourcentage des réponses d'évitement au cours de la période d'apprentissage (Tableau I), on constate que la performance des deux groupes d'animaux s'est améliorée régulièrement du début à la fin de l'expérience. Une comparaison du rythme d'accélération dans l'apprentissage des deux groupes (test U de Mann-Whitney) ne révèle aucune différence significative.

[3]Il est bon de noter ici que ces deux rats ont réussi à atteindre le critère d'apprentissage dans une expérience ultérieure dont le but était de vérifier la dégénérescence du cortex de la glande surrénale.

TABLEAU I

POURCENTAGE DES RÉPONSES D'ÉVITEMENT (COURBE DE VINCENT)

		Période d'apprentissage									
Groupes	*N*	1	2	3	4	5	6	7	8	9	10
Normaux	8	7.2	19.8	39.4	57.6	67.7	85.0	80.3	94.4	100.0	100.0
Hypophysect.	7	3.2	26.6	40.1	46.4	57.9	53.5	73.0	79.4	84.1	94.1

Tous les rats semblent capables d'apprendre à éviter un stimulus nocif. Le font-ils tous de la même façon? L'hypothèse déjà formulée veut que les rats hypophysectomisés aient un temps de réaction plus lent. Une comparaison des deux groupes, par rapport au temps de latence des réponses d'évitement, révèle en effet que le rat hypophysectomisé réagit au signal moins rapidement que le rat normal. La différence entre les courbes de Vincent des deux groupes (Tableau II) est significative au niveau 5 pour cent (test U).

TABLEAU II

TEMPS DE LATENCE, EN SECONDES, DES RÉPONSES D'ÉVITEMENT (COURBE DE VINCENT)

		Période d'apprentissage									
Groupes	*N*	1	2	3	4	5	6	7	8	9	10
Normaux	8	7.50	5.13	5.53	3.95	3.97	2.57	2.87	3.81	3.13	3.06
Hypophysect.	7	6.00	4.53	6.18	6.15	5.84	5.18	5.32	3.99	3.80	5.43

Cette différence dans le temps de réaction de la réponse d'évitement ne semble pas pouvoir être attribuée à une diminution d'activité générale chez le rat hypophysectomisé. En effet, si on compare le temps de réaction au SNC durant les deux premières journées, alors que les rats des deux groupes donnent beaucoup de réponses d'échappement, on voit que la latence moyenne du groupe témoin (4.91) est plus grande que celle du groupe expérimental (4.56). Il faut donc conclure que dans le cas du SNC les rats hypophysectomisés réagissent au moins aussi rapidement que les autres.

Le comportement général des rats dans l'appareil est difficile à évaluer quantitativement. Toutefois le nombre de défécations a souvent servi à l'interprétation du niveau d'anxiété d'un animal. Du début à la fin de l'apprentissage, on a tenu compte du nombre de défécations de chaque rat par séance. Si l'on distribue ces données sur une courbe de Vincent (nombre moyen de défécations par essai pour chacun des deux groupes d'animaux), on constate (Tableau III) que les rats hypophysectomisés

ont un nombre beaucoup plus considérable de défécations, et ceci tout le long de la période d'apprentissage. L'absence de recouvrement dans les résultats des deux groupes révèle à l'évidence que ces données sont significatives au plus haut degré.

TABLEAU III

NOMBRE MOYEN DE DÉFÉCATIONS PAR ESSAI (COURBE DE VINCENT)

		Période d'apprentissage									
Groupes	*N*	1	2	3	4	5	6	7	8	9	10
Normaux	8	.45	.46	.51	.56	.58	.60	.67	.71	.65	.66
Hypophysect.	7	.74	.87	.87	.91	.97	.93	.84	.87	.86	.85

DISCUSSION

Les résultats de cette expérience démontrent que les rats hypophysectomisés sont capables d'apprendre à éviter un stimulus nocif. D'ailleurs, dans une expérience plus récente, Applezweig et Moeller (2) en arrivent à des résultats identiques. L'hypophysectomie n'a pour effet que de ralentir la réaction au SC. A ce sujet il est intéressant de noter que deux études indépendantes, utilisant des méthodes différentes, donnent des résultats équivalents. Comme Applezweig et Moeller, nous ne croyons pas qu'on puisse invoquer l'hypothèse de la débilité chez les rats hypophysectomisés pour expliquer la lenteur de leur réaction au SC. En effet, puisque ces rats sont capables de réagir aussi rapidement que les autres au SNC, il est bien évident qu'il s'agit là d'un effet spécifique qui porte uniquement sur la réaction au SC, c'est-à-dire au signal d'un stimulus nocif imminent. On dirait que ce signal n'a pas pour eux le même caractère d'urgence que pour les rats normaux.

Cette lenteur des rats hypophysectomisés est-elle donc l'indice d'un niveau d'anxiété moins élevé? A la suite d'une expérience utilisant la technique de Brown, Kalish, et Farber pour l'étude de l'acquisition d'une réponse de peur conditionnée, Applezweig et Moeller (2) ont noté que le rat hypophysectomisé est incapable d'un tel conditionnement. S'appuyant sur ces données, ils concluent que ces rats ont un niveau d'anxiété très bas, ce qui expliquerait la lenteur de leur réaction au SC. Devant cette interprétation, on pourrait objecter que, durant la période d'apprentissage, la défécation des animaux hypophysectomisés est plus abondante que celle des rats normaux. On sait que plusieurs études, dont une toute récente de Broadhurst (4), tendent à démontrer que la défécation est un des plus sûrs critères d'anxiété chez le rat. Si on adopte ce critère, il faut

conclure que les rats hypophysectomisés de notre expérience sont plus anxieux que les rats normaux.

Il semble que ces résultats et ceux qu'ont obtenus Applezweig et Moeller au test de Farber ne sont pas inconciliables. Nous croyons comme eux que l'hypophysectomie affecte le niveau d'anxiété; mais n'est-il pas possible que l'absence de l'hypophyse ait pour résultat d'élever ce niveau d'anxiété à un point tel qu'il nuise à la performance? Si on suppose en effet que, comme pour la tension musculaire (**5**, **6**, **9**), la résistance galvanique de la peau (**8**) et les ondes cérébrales (**11**), la relation entre l'anxiété et la performance se traduit graphiquement par une courbe en U, il est possible que, une fois passé le point optimum, toute augmentation du niveau d'anxiété corresponde à une baisse de la performance qui expliquerait la difficulté d'acquérir une réaction conditionnée à la peur. Par contre, ce serait à partir de ce niveau élevé d'anxiété qu'entreraient en jeu les réactions du système autonome, responsables d'une défécation excessive.

Quoi qu'il en soit, cette confusion soulève des doutes sur la valeur opérationnelle du concept d'anxiété tel qu'utilisé dans le présent contexte et dans la théorie de Mowrer.[4] MacCorquodale et Meehl (**13**) croient en effet que ce concept ne rencontre pas les exigences strictes d'une variable intermédiaire; le terme aurait plutôt une signification vague ou trop vaste et se référerait à un processus qui n'est pas directement observable. Il y aurait avantage, semble-t-il, à le remplacer par un concept beaucoup plus empirique, celui d'activation ou de vigilance (*arousal*) (**7**, **10**, **12**) dont on a déjà étudié les rapports avec la performance (**3**, **14**, **18**).

Toutes les données déjà accumulées indiquent, comme le faisait remarquer Duffy (**7**), que cet état de vigilance correspond à l'état de motivation. Lorsque la vigilance est excessive, i.e., dépasse le point optimum, on obtient une désorganisation du comportement que l'on a souvent attribuée à une trop forte motivation, à l'émotion, ou à l'anxiété. Ce n'est que dans le schéme théorique de Mowrer qu'on voit l'anxiété, agent de renforcement, exercer une action positive sur la performance. L'expérience clinique et l'étude du comportement des rats dans une situation d'échappement-évitement invitent plutôt à considérér l'anxiété comme le symptôme d'un excès de vigilance (Malmo (**14**) parle à ce

[4]Cette critique ne s'adresse pas directement à la théorie de Mowrer sur les deux facteurs de l'apprentissage, théorie d'ailleurs reformulée depuis (*Psychol. Rev.*, 1956, **63**, 114–127). L'auteur suggère tout simplement que, dans les études des effets de la modification des systèmes physiologiques sur l'apprentissage, l'on utilise de préférence comme variables intermédiaires des concepts définissables en termes de mesures physiologiques.

propos d'une maladie de survigilance, "disease of overarousal") ou tout simplement comme une vicissitude de la vigilance.

De toute façon, il semble bien que l'interprétation du rôle de l'hypophyse dans l'apprentissage oblige à définir les rapports existant entre les secrétions de cette glande et le niveau de vigilance.

SUMMARY

To determine the effects of hypophysectomy on psychological adaptation, the performance of seven hypophysectomized rats in an escape-avoidance situation was compared with that of eight normals. The hypophysectomized animals were capable of the learning required, but their reaction to the CS was significantly slower than that of the controls. These findings agree with those of other workers (**1**, **2**).

However, the hypophysectomized rats also defecated significantly more in the learning situation than did the controls. Hence their slower reaction to the CS can hardly be due to a lower level of anxiety, as Applezweig and Moeller concluded from some of their results (**2**), but might better be attributed to the raising of anxiety to a level which interfered with performance. The apparent conflict here reflects the inadequacy of the concept of anxiety as used in Mowrer's theory (**16**), and would disappear if "arousal" (**7**, **10**, **12**) were substituted for anxiety. The concept of arousal can handle all the findings reviewed here, and it also satisfies much better the conditions of a true intervening variable.

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SERIAL ADDITION AS A FUNCTION OF STIMULUS DURATION AND PACING

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In a series of experiments (2,3) a paced serial addition task was administered to subjects several times. Some subjects encountered the identical pacing rate on each administration of the task; others met a different one, randomly determined, each time. Results revealed that, with pacing constant and stimulus duration varied, percentage correct depended on pacing alone and not on stimulus duration (within the limits studied). In contrast, with different pacing rates presented randomly and stimulus duration again varied, percentage correct depended on both stimulus duration and pacing.

Under both experimental conditions, the more rapid pacing rates were associated with poorer performance. With pacing varied randomly, however, the longest stimulus duration within each pacing interval was generally associated with the best performance recorded at that pacing rate. To account for this it was assumed that varying pacing introduced a source of disturbance additional to speed of pacing, and that this was minimized under longer stimulus durations (3).

What is not clear from these studies is whether this additional disturbance was due to the changes in pacing rate *per se*, to the fact that these were randomly presented, or to the changes in stimulus duration that accompanied each change in pacing, to mention only three possibilities. The present experiments were concerned with these problems, and aimed to answer the following specific questions: (1) Is the value of longer stimulus durations within pacing intervals lost if changes in stimulus duration are presented unsystematically while pacing rates are increased systematically? (2) Is the value of longer stimulus durations lost if changes in pacing rates and stimulus duration both occur systematically?

Method

Sixty-one digits from 1 to 9, randomly ordered in a fixed series, were projected under experimental conditions that permitted exposure time for individual digits and rate of presentation to be varied.

The subject was required to add the number before him on a dimly illuminated day-view screen to the one that immediately preceded it and to call out his answer. If he made a mistake or missed a number, he could cut back into the series by not responding to one number and adding to it the next one to appear.

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The subject was never told whether he was correct. His responses were recorded by *E* on prepared answer sheets containing the series of stimuli and correct responses.[1]

Subjects

The 20 Ss used in these experiments were male high school students who had just completed one year beyond High School Graduation, i.e., Upper Sixth Form. They ranged in age from 17 to 19 yrs.

Before the experiments each *S* worked on the serial addition task with pacing set at 1 digit every 1.4 secs. and stimuli "on" 0.9 sec. and "off" 0.5 sec. The task during this pre-training was identical with that in the experiments and *S*'s verbal responses were recorded in the same way. This pre-training was to ensure that S was familiar with the operations required, and to provide an added check on the comparability of the groups used.

Procedure

In both experiments pacing was gradually increased from 1.6 secs. per digit to 1.4, 1.2, 1.0, and 0.8 secs. Identical sets of on-off ratios were also used in each experiment. These were: (A) stimuli "on" 1.2, 1.0, 0.8, and 0.6 sec. and "off" 0.4 sec.; (B) stimuli "on" 0.4 sec. and "off" 1.2, 1.0, 0.8, 0.6, and 0.4 sec. The only difference between the experiments was in the order of presentation of these 9 on-off ratios.

Experiment I dealt with effects of changes in stimulus duration with pacing increased at every other administration of the task. The nine on-off ratios were assigned randomly to each S, but (unlike previous experiments) each pacing frequency occurred twice in succession, with a different stimulus duration each time. The latter might be either the longer or the shorter of two durations used in each pacing interval. Which would occur first was determined randomly. An exception was the condition in which stimuli were "on" 0.4 sec. and "off" 0.4 sec. This 0.8 sec./digit pacing interval was administered only once. Ten Ss (Group I) took part in the experiment.

In Experiment II the effects of the same stimulus durations were studied under conditions in which changes both in stimulus duration and in pacing were systematic. Ten Ss (Group II) took part in the experiment. They were divided into two sub-groups of five. The on-off ratios shown above were administered, in the order indicated, to both sub-groups in an ABBA design. Again the exception was the condition in which stimuli were "on" 0.4 sec. and "off" 0.4 sec. This experimental condition always followed directly the set of conditions (A or B) that was given first.

The nine on-off ratios were administered to S in the sequences indicated, in one session, with a brief interval between successive administrations of the task.

Results

Pre-training performance. There was no significant difference between the groups in mean percentage of correct answers obtained during pre-training when stimuli were "on" 0.9 sec. and "off" 0.5 sec. (Group 1, $\bar{X} = 85.5$; Group II, $\bar{X} = 83.5$).

Experimental performance. Salient features of the performance of these

[1] Details of apparatus used in these experiments can be found in references 2 and 3.

TABLE I

ANALYSIS OF VARIANCE OF PERCENTAGE CORRECT OBTAINED BY 20 MALE STUDENTS ON A SERIAL ADDITION TASK UNDER 5 DIFFERENT PACING CONDITIONS WITH 9 ON-OFF RATIOS

Source of variation	Sum of squares		df	Mean square	*F*
Between Groups I and II	31.8		1	31.8	n.s.
Within groups	7369.4		18	409.4	
Total between subjects		7401.2	19		
Between on-off ratios	14556.4		8	1819.6	37.83**
Ratios × Groups	1203.0		8	150.4	3.13**
Pooled subjects × Ratios	6926.5		144	48.1	
Total within subjects		22685.9	160		
TOTAL		30087.1	179		

**Significant beyond the 1 per cent level of confidence

groups during the experiments are illustrated in Figure 1. A summary of analysis of variance (1) of percentage correct[2] is shown in Table I.

It can be seen from Table I that there was no significant difference between the groups in mean percentage of correct responses obtained under the various experimental conditions. However, in both groups there was a highly significant decrease in percentage correct with systematically increased pacing. Table I shows also that there was a significant Ratios × Groups interaction. This points to some differences between the groups in course of performance despite similarity in mean performance.

Solid lines in Figure 1 represent performance of Group I; broken lines, performance of Group II. In each instance the upper line of each pair of curves represents performance under the longer of the two stimulus durations used in each pacing interval; the lower line, performance under the shorter duration.

Figure 1 shows clearly the general superiority of performance under the longer stimulus durations. This trend was confirmed by sequential testing of means by a method devised by Hartley (4). This superiority of the longer stimulus durations holds in both groups until pacing reaches 1.0 sec./digit.

The Ratios × Groups interaction is also depicted in Figure 1 by differences in slopes of lines through the mean percentage correct obtained by each group. This difference between groups in the curves of performance can be attributed to comparatively higher performance levels attained in Group I, particularly when pacing was 1.0 sec./digit and 0.8 sec./digit, as compared with Group II under the same conditions.

[2]These data were all transformed by the formula: Angle = Arcsin $\sqrt{\text{Percent correct}}$ before analysis (4).

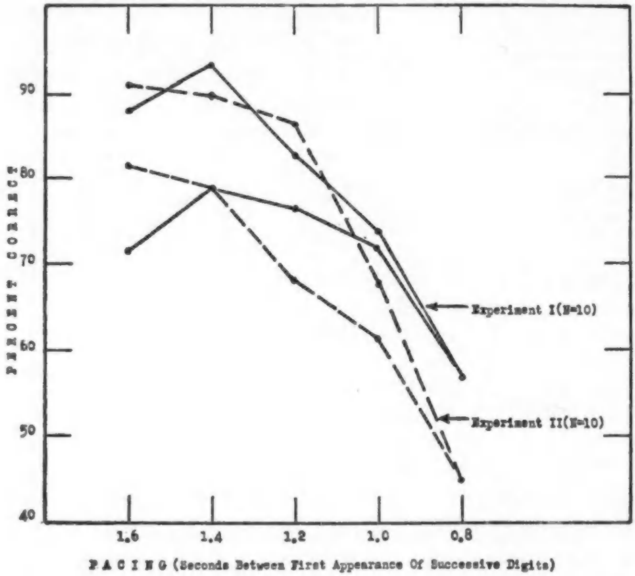

FIGURE 1. Performance of 20 male high school students on the serial addition task with pacing and stimulus durations varied. The upper line of each pair of curves represents percentage correct under the longer of two stimulus durations used in each pacing interval; the lower line percentage under the shorter duration.

This difference was most marked when stimuli were "on" 0.4 sec. and "off" phases were varied.

Discussion

Experiment I shows clearly that under these experimental conditions performance on the serial addition task was a joint function of pacing rate and stimulus duration. This means that when pacing is systematically increased, the value of prolonging stimulus duration within pacing intervals is not lost.

Moreover, the supporting value (3) of the longer stimulus durations within pacing intervals was not affected by the two successive administrations of the task under identical pacing conditions in Experiment I. The procedure resulted in a significant Ratios × Groups interaction, indicating that this procedure served only to raise over-all performance level in Experiment I.

Finally, it will be recalled that the procedures used in Experiment I required a number of successive administrations of the task itself under a variety of pacing rates. This might have provided S with the oppor-

tunity to anticipate the direction of pacing changes and so have made his task easier. If this had been the case, one might expect the value of longer stimulus durations to have been lessened. Results indicate that this was not so.

This possibility was also not supported by the results of Experiment II. In Experiment I Ss might have anticipated changes in pacing. They could not as readily have anticipated stimulus durations. Thus a degree of randomness was retained in the presentation of stimuli in Experiment I. This was further reduced in Experiment II. Here the changes both in stimulus duration and in pacing were made systematically. Nevertheless, performance in Experiment II was still a function of both variables. Hence opportunity to anticipate one or both variables in these experiments does not seem to have affected performance.

Present results resemble those reported earlier (3) in which the orders of presentation of the two variables were randomized. The similarity of results suggests that the order of presentation of either pacing rates or stimulus durations plays no significant role in performance on the paced serial addition task.

These findings make possible a more adequate account of the factors influencing performance under these testing conditions. First, it is clear that it is pacing and not some artifact of the order of presentation of pacing rates that is one source of the disturbed performance. It would even seem that only a certain level of performance is possible on the average under the pacing conditions used in these experiments. In the present experiments there was also an increasing disturbance of performance associated with systematically increased pacing. A similar disturbance under pacing has occurred in all the experiments and is characterized in each instance by significantly fewer correct answers accompanied by increased blocking (stimulus omissions) rather than wrong answers. Finally, results to date point to a second disrupting factor. This is *change* in pacing which seems to be the source of the additional disturbance that is offset by prolonging stimulus durations within pacing intervals. The disturbance due to pacing rate *per se* seems independent of this latter effect.

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THE BENDER GESTALT TEST: MANNER OF APPROACH

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WRITING in Abt and Bellak's *Projective Psychology*, Woltmann describes how Bender Gestalt figures are typically copied, and suggests that "the manner in which the Gestalten are copied may reveal important clues that are undiscernible in the finished record" (1, p. 329). However, he presents no data, or references to data, to support his assertions about the typical manner of copying, and provides only one example in which a deviation from the typical seemed to have diagnostic significance.

The present study, therefore, was specifically concerned with: (*a*) establishing empirically the typical manner of approach to the BG test, and (*b*) testing the hypothesis that deviations from it are related to poor mental health.

METHOD

Subjects

Meticulous study of the in-patient case material provided a sample of 8 male and 8 female patients whose conditions had been diagnosed as either catatonic or paranoid schizophrenia by both the attending psychiatrist and a medical conference. These patients were selected so that the sexes were equally represented in each diagnostic category. A group of 8 nurses or nurses' aides and 8 attendants was selected from 48 volunteers to match the patient group on the variables of age and education. The age ranges for patients and controls were 20–52 and 23–53 respectively; educational ranges in years were 8–17 for patients and 8–16 for controls. All Ss were English-speaking, and none had any serious physical disability. None of the patients was under any form of treatment.

Testing Procedure

The Ss were tested individually in the standard manner described by Pascal and Suttell (2). Recording of the manner of approach was facilitated by use of a sheet of paper upon which the BG figures had been mimeographed. The observer indicated on this sheet, by appropriate use of letters, numerals, and arrows, which parts of the figures S did first, which direction he proceeded in, etc. When S had completed the test, his drawings were removed from view and he was requested to draw as many of the figures as he could from memory. His manner of approach was again recorded. The S was given a minimum of 3 and a maximum of 8 minutes to complete this part of the test.

RESULTS

Table I indicates clearly that the ways described by Woltmann of approaching the Bender Gestalt figures are indeed typical. They do not, however, differentiate between the patient and control groups.

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TABLE I

Manners of Approach to the BG Figures according to Woltmann and their Frequency in the Control and Patient Groups

Figure	Typical approaches (Woltmann)	Controls ($N = 16$)	Patients ($N = 16$)
A	Circle, then diamond	15	13
1	Left to right	16	14
2	Left to right in groups of three	16	13
3	Left to right in 1, 3, 5, and 7 dot sequence	15	13
4	Open square followed by curve	16	14
5	Semi-circle of dots, then straight line of dots	12	12
6	Horizontal wavy line followed by vertical line	13	14
7	Vertical figure first, slanting second (reversal common)	4	6
8	Elongated figure first, diamond second	15	16

Results of a more detailed analysis of the manner of approach, revealing additional consistencies, are presented in Table II. Again it is clear, both that a definite tendency for the drawings to be done in specific ways exists, and also that these ways are common to patients and controls.

A general feature of all typical approaches is the tendency to follow a reading and writing sequence, i.e., from left to right. This seems to be the manifestation of an overlearned visual-motor habit. Assuming that one of

TABLE II

Typical Features of the Approaches to BG Figures by Controls and Patients

Figure	Feature	Controls ($N = 16$)	Patients ($N = 16$)
A	(1) Counterclockwise direction circle	15	10
	(2) No single direction in diamond*	9	12
2	(1) Counterclockwise direction on loops	10	7
	(2) Top to bottom on groups of three circles	14	14
3	(1) Top to bottom of rows on dots	12	11
4	(1) Open square, counterclockwise direction	8	8
	(2) Bell-shaped curve, right to left	11	8
5	(1) Semi-circle of dots, left to right	12	13
	(2) Oblique line, bottom to top	9	14
6	(1) Horizontal wavy line, left to right	16	15
	(2) Vertical line, top to bottom	11	8
7	(1) No single direction used in either figure*	11	12
8	(1) No single direction used in elongated figure*	12	11
	(2) No single direction used in diamond*	11	12

*The S did not go around the figure in a single clockwise or counterclockwise direction, but rather drew one side of the figure clockwise, another counterclockwise, etc.

the outcomes of mental illness is the disruption of such habits, one might predict that patients would tend towards an atypical manner of approach –or, more broadly stated, that in any population the degree of "atypicalness" would be correlated with diminution of ego strength.

This hypothesis was checked by correlating the BG z scores of all 32 subjects with their scores for atypical approach. The latter were calculated simply by adding up the number of instances in which the subject did not do the drawings in the manner indicated in Tables I and II. The possible score range for "atypicalness" was thus 0–23. (The actual range of atypicalness scores was 2–15; the range of z scores was 33–188.) The resulting Pearson r was –0.011, which is clearly not significant. The results of the memory section of the test were essentially the same as those for the performance proper.

Discussion

It seems obvious that there does exist a fairly typical manner of approach to the Bender Gestalt figures. It is similarly obvious that deviation from this typical approach is not directly related to the dimension of ego control as here measured. This study leaves unanswered, however, the question as to whether specific atypical manner-of-approach features are related to more specific aspects of psychopathology. We were unable to discern any differences between the deviations of the paranoids and of the catatonics, but the small *N*s do not warrant any definite conclusion on this point. In any case, the results of this study should not be construed to mean that the patient's manner of approach to the BG may be disregarded. Qualitative observation of such behaviour as counting dots, numerous erasures, etc., contributes much to the richness of BG interpretations.

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STIMULUS COMPLEXITY AS A DETERMINANT OF THE REACTION TIME OF SCHIZOPHRENICS[1]

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IN DISCUSSING the conditions under which "psychological deficit" becomes manifest, Hunt and Cofer (2) summarize work from the Worcester State Hospital and elsewhere and state: "as the complexity of performance increases, the slowness of schizophrenics becomes progressively more marked." Because none of the studies reviewed by these authors covered a large range of task complexity, an experiment where this would be the case seemed called for.

It has been shown by Hick (1) and Hyman (3) that reaction time in normal subjects is linearly related to stimulus complexity, defined as the log of the number of equiprobable stimuli to which response may be made. Assuming that "complexity of performance" in Hunt and Cofer's statement may apply to stimulus complexity, it is possible to set up two alternative hypotheses. These are that the reaction time of schizophrenic subjects is either: (*a*) a linear function of the log of the number of equiprobable stimuli ($\log_n$), having a slope steeper than that shown by normal subjects; or (*b*) a positively accelerated curvilinear function of $\log_n$, with an initial rate of change not less than that of the linear slope shown by normals.

The present experiment was designed to test these hypotheses over a range of from one to eight equiprobable alternatives.

Following Hyman (3), and in order not to introduce response complexity as a source of variance, verbal response was used.

METHOD

Apparatus

Eight stimulus lights (3-watt M.E.S. bulbs with ¾-inch diameter plastic covers) were set in a 2′ × 2′ matt blackboard at the corners of two superimposed parallel-sided squares having sides of 4½ and 8½ inches. The covers of the lights had the numbers 1 to 8 painted on them, 1 to 4 at the corners of the inner square and 5 to 8 at the corners of the outer square. The subject sat 3 feet from the display. Numbered lights, rather than lights whose names had to be learnt as in Hyman's experiment, were used to make the task easier for schizophrenics.

[1]This work was carried out at Springfield Hospital, London, by kind permission of the Medical Superintendent, Dr. H. C. Beccle.

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The stimuli were presented every 8.5 sec. and the verbal response of the Ss, via an amplifier and shaping circuit, operated a relay which terminated the stimulus. The maximum error in timing due to delay in this circuit was found to be 5 milliseconds. Reaction time was measured to the nearest millisecond by an electronic decade timer.

Subjects

Group 1 comprised 8 male open ward schizophrenic Ss with mean age 39.0 and S.D. 5.9 years, who were each tested on 4 occasions. Group 2 comprised 8 male schizophrenic Ss with mean age 40.8 and S.D. 8.7 years, who displayed more marked schizophrenic signs than Group 1. These were each tested on a single occasion. Eight male normal controls with mean age 37.4 and S.D. 4.6 years formed Group 3. These controls also were each tested on a single occasion.

Procedure

In a preliminary practice session it was explained to the S that all he had to do was to say as quickly as possible the number on a light as soon as it was lit. He was given sufficient practice to be familiar with the situation.

Each S then performed under each of the 8 degrees of stimulus complexity in the order given by the row of a balanced Latin square to which he was allocated. Subject number 1 of Group 1 (tested on 4 occasions) used rows 1, 2, 3, and 4; subject number 2 rows 2, 3, 4, and 5, and so on. Different combinations of lights were used for every S for each degree of complexity, and within each complexity series the appearance of stimuli was determined by use of random number tables, with modifications to avoid obvious alternation patterns. Approximately 20 stimuli were given in each complexity series, in such a way that each stimulus light appeared an equal number of times. When stimulus lights were not being used they were covered with an opaque cap. Whenever the degree of complexity was changed the experimenter said, for example, "now we will use seven lights."

Results

The mean RTs for each complexity and for each group are shown in Figure 1 together with the best fit linear regression line for each set of mean data.

The data from the eight schizophrenic Ss in Group 1 who performed on four occasions were first examined for evidence to indicate whether or not RT was related curvilinearly to the log of the number of equiprobable alternatives. Analyses of variance carried out on each S's data individually produced no evidence to support the hypothesis of curvilinearity. The F ratios for df 6 and 24 were 1.55, 0.71, 1.05, 0.23, 0.79, 0.39, 0.36, 1.15. To be significant at the .05 level F would have to exceed 2.51.

When the data for the eight more disturbed schizophrenic Ss in Group 2 were analysed as a whole for curvilinearity, F for df 6 and 58 was 0.18 (the .05 level is approximately 2.3). This F ratio can be shown by inversion to be significantly small; however, further examination of the data shows that this result is due to a large array variance and is not a product of interaction effects.

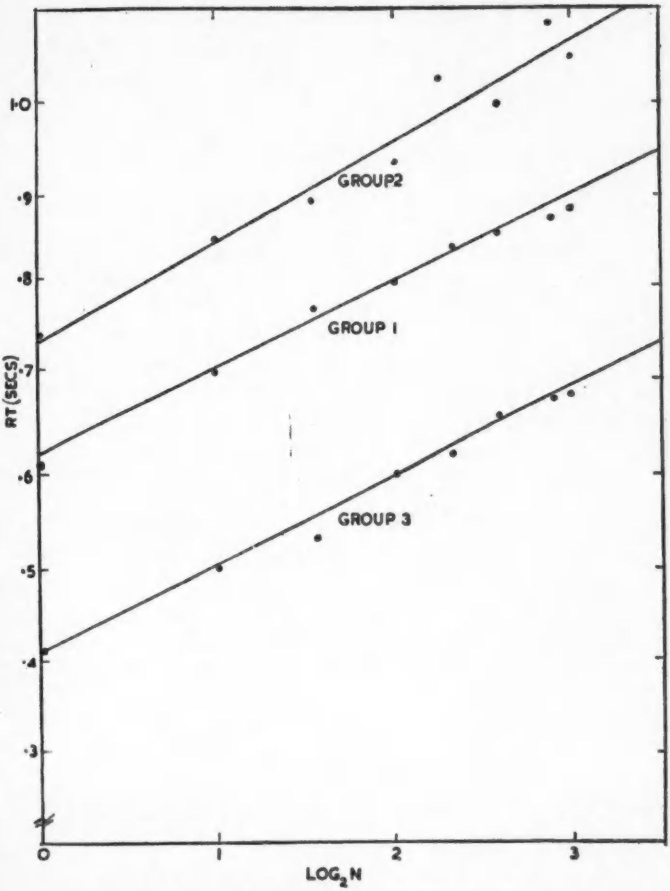

FIGURE 1. Reaction times of schizophrenics (Groups 1 & 2) and normals (Group 3) plotted as a function of log stimulus complexity.

These analyses and graphic examinations of individual curves show that the hypothesis of a curvilinear relation between RT of schizophrenic Ss and stimulus complexity is untenable.

An analysis of variance was carried out to examine the tenability of the hypothesis of differences between schizophrenic and normal groups in the slope of the function relating RT and stimulus complexity. While highly significant values for variances between groups and between complexities were found ($F = 97.19$, $P < .001$, and $F = 11.20$, $P < .001$,

respectively), the variance due to group $\times$ complexity interaction was not significant ($F = 0.17$). Thus the hypothesis of difference in regression slopes between schizophrenics and normals is not upheld.

That the reaction times obtained for each group are linearly related to the log of the number of stimulus alternatives is confirmed by linear correlations of RT with $\log_n$ of 0.998 for Group 1, 0.963 for Group 2 and 0.993 for Group 3.

There was no difference between the number of errors made by the schizophrenic and the normal groups, the percentage in each group being around 0.5.

The above results indicate that, when only the stimulus side of task complexity is manipulated, schizophrenics do not show increasing deficit with increasing complexity. Full evaluation of Hunt and Cofer's statement would require further experiments in which there is variation in complexity of response.

Summary

The hypothesis that schizophrenics would be increasingly slower than normals with increase in stimulus complexity was tested by comparing choice reaction times to from one to eight equiprobable stimuli. Subjects used were sixteen schizophrenics and eight normal controls; a simple verbal response was required. The slowness of the schizophrenics as compared with the normals showed no increase over the range of stimulus complexity used.

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ABILITIES AND INTERESTS: I. A FACTORIAL STUDY[1]

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A WORKING ASSUMPTION in applied human psychology, as evidenced by available psychological tests, is that measured abilities and measured interests are not necessarily related, pattern to pattern, in any particular way. Experience with measures of these dimensions in counselling situations suggests, however, that certain interest-ability configurations occur with more than chance frequency. This study was designed to reveal such configurations by exploring the relationships between measured interests and abilities.

There are many studies of the relationships between interests and abilities in the literature (3, 8, 17, 25, 27). Most explore the relation between a specific ability and a specific interest, some the relation between patterns of interest and a single ability measure, and a few (e.g., that of Adkins and Kuder (1)), the relation between interest patterns and ability patterns. The results of these studies have been inconclusive, lending as much support to Berdie's (5) conclusion that interests and abilities are not significantly related as to Strong's (27) conclusion that they are.

Although Super (28) has claimed that there is no satisfactory theory of interests, Murphy (23) has suggested that interests are overlearned responses. He contends that the concept of overlearning is the only one that makes the consistency of interests over long periods of time understandable. Assuming long-term continuity of goals as the basic dynamic, Murphy uses Janet's term *canalization* to refer to the process by which more and more of these goals are incorporated in the personality, while at the same time the goals become increasingly specific. The strength of the canalizations is a function of biologically determined preferences and of the frequency of opportunities provided for specific responses. Canalizations differ from conditioned responses largely in their resistance to extinction, and in the role that consummatory responses play in their formation. A parallel line of reasoning has been marshalled by Ferguson (12) to support his contention that abilities, as measured by ability tests, are also overlearned behaviour patterns. Noting the resistance of abilities to extinction, and their stability irrespective of use or disuse, he argues

[1]Based on a thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy at McGill University, 1956; and supported in part by Grant No. A.P. 21 of the National Research Council.

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that ability test scores denote limits of learning. These limits are functions, he believes, of biological and environmental factors which determine which particular abilities will be exercised and how far they will be developed at any stage in the maturation process.

These attempts to supply theoretical bases for interests and abilities provide for some of their outstanding characteristics—stability and resistance to extinction especially—by making learning the central dynamic, and by drawing attention to the role of overlearning. The obvious parallels between the independent formulations of Murphy and Ferguson, and their convergence on the same underlying mechanisms, provide additional support for attempts to demonstrate significant interest-ability relationships.

Such relationships might best be defined as overlearned behaviour patterns, "traits" in the language of Allport and Eysenck. Eysenck defines traits as "observed constellations of individual action-tendencies" (11, p. 28) and illustrates them as being composites of habitual responses. His use of the concept is congruent with that of Allport (2), who has advanced a set of criteria which such attributes of behaviour should meet in order properly to be called traits. These criteria include requirements that traits be defined operationally, more generalized than habits, dynamic, capable of identification through statistical methods, etc. The composite factors postulated by the foregoing discussion would satisfy all of Allport's criteria, and hence may properly be considered as personality traits with integrative and dynamic characteristics.

A factorial approach to the analysis of such relationships follows precedents established by Thurstone (29), Strong (27) and Lurie (21) for interest inventories; and Burt (6), Carroll (7), Cattell (9), Schiller (24) and the Thurstones (30, 32) for intelligence and ability tests.

Procedure

The test battery included the Verbal Reasoning, Numerical Ability, and Abstract Reasoning tests of the *Differential Aptitude Tests* (4), *the Chicago Tests of Primary Mental Abilities, Single Booklet Edition* (33), the *Kuder Preference Record—Vocational, Form BB* (18), and the *Kuder Preference Record—Personal, Form A* (19). These are referred to in the tables as DAT, PMA, KV, and KP, respectively. The tests were administered to a group of Day College freshmen at Sir George Williams College as part of the regular programme of Orientation Week, and were administered and scored in complete accordance with the instructions in the appropriate manuals. The experimental sample consisted of 135 students who attempted every test and inventory during the formal testing programme. Thirty-five of these subjects were females. Age range was 16 to 22, with 17 the modal age. An Arts study programme claimed 37.7 per cent of the sample, Commerce 32.5 per cent, and Science 29.6 per cent.

TABLE I

The Correlation Matrix
(Original correlations to the right of the diagonal, residuals to the left.)

Variable	Code no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Sex	1		−26	14	−01	−20	−03	−30	04	16	22	−49	−20	−20	−30	26	08	18	39	−03	10	00	23	43	−31
DAT Numerical	2	02		26	42	31	20	34	11	32	−02	20	32	18	00	00	−18	−33	−21	05	20	11	−16	−13	07
DAT Verbal	3	04	04		58	−15	72	33	40	54	26	−07	−19	−04	03	10	20	−18	05	−19	−17	00	12	00	−01
DAT Abstract	4	05	08	−03		−04	42	50	16	49	09	10	09	12	−03	05	03	−13	−23	00	−26	−03	−02	−10	−08
PMA Numbers	5	01	09	01	01		−06	−06	08	−01	−06	00	36	09	−11	−23	−13	−10	−05	25	01	13	−17	−05	−02
PMA Ver. Mean.	6	00	03	03	00	00		27	53	42	21	02	−21	07	11	01	14	−21	−04	−20	−13	−06	05	−11	06
PMA Space	7	−10	−07	−02	01	−09	00		21	42	−08	34	17	17	04	13	−27	−07	−26	−03	−20	01	−19	−13	−06
PMA Word Flu.	8	−03	−06	−07	01	01	04	09		41	32	−19	−16	−17	11	01	18	−09	13	−06	03	07	12	01	−01
PMA Reasoning	9	01	−01	00	−02	01	−02	04	05		24	−03	10	05	−04	11	−06	−07	00	−01	−05	−13	−05	−03	−05
PMA Memory	10	−01	04	02	02	−04	−03	−06	00	04		−20	−07	−26	20	11	14	08	−03	08	−04	−10	04	09	−04
KV Mechanical	11	−03	00	04	00	−04	−01	01	01	−01	02		28	53	10	12	−48	−30	−56	−13	−24	03	−55	−38	16
KV Computat.	12	−01	05	−01	−03	02	−06	03	−01	−02	00	03		33	−17	−18	−42	−19	−29	44	−20	00	−31	−14	14
KV Scientific	13	01	04	−08	00	00	00	−01	−01	02	00	04	01		−35	−08	−38	−36	−21	−21	−36	28	−12	−07	−11
KV Persuasive	14	−02	−03	03	01	−08	−01	01	−02	00	05	03	−03	−01		−08	17	−04	−29	05	20	−36	−20	−36	45
KV Artistic	15	05	06	−01	−03	01	−04	−03	01	−04	01	−07	−05	−10	−06		−25	−04	−25	−31	−10	−08	−24	07	−28
KV Literary	16	01	02	−01	00	00	−06	−07	04	04	00	−04	−05	−03	−01	02		13	12	−05	02	−14	49	06	18
KV Musical	17	−06	−14	−05	−04	04	01	12	05	06	01	02	−02	−02	−07	−07	−05		01	06	11	−19	22	23	−14
KV Soc. Serv.	18	03	−08	05	−01	−04	−01	02	−02	01	00	−04	−02	−13	04	−07	−08	−08		−17	30	30	51	37	−14
KV Clerical	19	03	−04	00	03	−02	01	02	03	−02	−02	−01	01	−06	01	−10	−06	−04	03		00	−08	−17	05	08
KP Sociable	20	09	10	02	−07	−03	02	−13	−05	−07	−03	00	−05	−02	03	00	−04	00	−07	04		−20	07	08	12
KP Practical	21	04	01	02	−01	−03	−08	−02	02	−03	−02	−01	−03	−04	03	−01	−03	−07	04	00	−06		15	39	−33
KP Theoretical	22	−04	00	−05	−02	−04	−03	05	05	−02	05	−01	03	06	−02	03	05	04	−03	−04	−04	05		30	−01
KP Agreeable	23	01	−02	02	−03	−05	04	00	−01	03	02	04	02	05	04	−02	03	00	−03	02	05	04	02		−51
KP Dominant	24	01	04	04	−03	−08	−01	−02	−01	−03	02	06	05	−03	07	−01	01	−04	04	02	02	02	02	02	

The score distributions on every variable were T-scored to a mean of 50.0 and a standard deviation of 10.0. Product-moment correlation coefficients for the 23 test variables, and point-biserial correlations relating sex to each of the other variables were computed. The resultant matrix (see Table I) was analysed by the method of centroid factor analysis (31) to yield eight factors. Rotation of axes by the method of two-dimensional sections (31) gave an oblique factor structure (see Table II).[2] The factors were then tentatively defined by reference to the variables with significant loadings.[3] An attempt was made to verify these tentative definitions by reference to independent factorial investigations of abilities and interests and also by using data related to the study programme of the sample. This latter phase of the validation will be reported in a subsequent paper.

TABLE II

ROTATED OBLIQUE FACTOR MATRIX V_R*

	Variable	Code No.	A	B	C	D	E	F	G	H
Sex		1	**.29**	.23	−.05	.07	−.09	.05	**.36**	−**.46**
DAT	Numerical	2	.06	**.35**	−.04	**.29**	−.05	.05	.12	**.57**
DAT	Verbal	3	.10	**.78**	.07	−.04	.18	.04	−.05	−.02
DAT	Abstract	4	.07	**.66**	.02	.21	.20	**.43**	.00	.23
PMA	Numbers	5	.09	−.01	.16	**.39**	−.03	−.23	−.05	.22
PMA	Verbal Meaning	6	−.05	**.64**	.13	−.09	.10	−.19	−.10	−.06
PMA	Space	7	−.02	**.44**	−.06	.11	−.14	.24	.02	**.37**
PMA	Word Fluency	8	.04	**.56**	−.04	.08	−.11	−**.46**	.01	−.02
PMA	Reasoning	9	.03	**.72**	.00	**.28**	−.08	.05	**.44**	.12
PMA	Memory	10	−.08	**.38**	−.15	.19	−.19	−.15	.00	−.30
KV	Mechanical	11	−**.32**	−.16	.24	−.19	−**.29**	.10	−.18	.17
KV	Computational	12	−.10	.03	**.37**	**.65**	−.07	.06	.17	.12
KV	Scientific	13	.13	−.08	**.65**	−.11	.05	−.01	−.04	.06
KV	Persuasive	14	−**.58**	−.02	−**.45**	−.08	−.10	−.07	−.16	.06
KV	Artistic	15	−.05	.19	−.19	−.16	−**.54**	.19	.13	−.20
KV	Literary	16	.02	.05	−.16	−.18	**.50**	−.04	−**.28**	−.13
KV	Musical	17	.10	−.11	−**.35**	.03	.03	.25	.01	−.09
KV	Social Service	18	**.49**	−.04	.12	−.14	.26	−**.34**	**.28**	−.01
KV	Clerical	19	−.01	.01	−.06	**.64**	.03	.16	−.11	.01
KP	Sociable	20	−.07	−.10	−**.43**	.02	−.06	−.14	**.33**	**.35**
KP	Practical	21	**.62**	−.01	**.34**	−.07	.04	−.16	−.26	.16
KP	Theoretical	22	**.36**	.02	.04	−.18	**.57**	−.06	.03	−.04
KP	Agreeable	23	**.73**	.11	−.09	.12	−.08	.07	.00	−.05
KP	Dominant	24	−**.62**	−.17	.01	−.03	**.28**	−.16	.03	.06

*Significant loadings in bold-face type.

[2]The complete history of the factor analysis and rotation of factors is contained in tabular form in David D. Smith, "The Relationship between Abilities and Interests: A Factorial Study," unpublished doctoral thesis, McGill University, Montreal, 1956.

[3]A significant loading was arbitrarily defined as a loading of absolute value equal to or greater than 0.27, equivalent to the $P = .001$ level of significance for zero order correlation coefficients where $N = 135$. An arbitrary criterion is necessary since the sampling distributions of factor loadings are unknown.

Identification of the Factors

The correlation matrix for this analysis consisted of the 253 product-moment correlation coefficients between the 23 test variables and the 23 point-biserial coefficients relating sex to each of the other variables. Eight factors were extracted. The residuals were normally distributed, the mean residual being equal to —.004, the model residual being .01. Application of Guilford's (**14**) criterion of factor significance requires that the product of the two highest loadings should not be much smaller than the standard error of a zero correlation. The product in this case is .078, and the standard error where $N = 135$ is .086.

Rotation by the method of two-dimensional sections resulted in a factor structure that adequately satisfied the criteria for simple structure. This structure was somewhat oblique.

Factor A

Variables with significant loadings for each factor are shown in Table II. It is evident that Factor A is a bipolar one on which none of the ability variables received significant loadings.

This factor, contrasting "taking care of, training, teaching, helping, etc." with "selling, interviewing, convincing, etc.," resembles the factor that Strong (**27**) located which has been called "working with people for their presumed good." This factor opposed the occupations of minister, social science teacher, YMCA secretary, and others to those of president, purchasing agent, production manager, and so forth. Cattell (**9**) combines the above factor of Strong's analysis with clusters produced by Gundlach and Gerum (**16**) in his suggested factor QI.Ib: "Guiding people for their own presumed good *v.* being coldly objective." Within the limits imposed by this study it appears that Cattell's factor QI.Ib and Factor A of this study are identical.

Factor B

This factor, extending in a positive plane only, is defined in terms of ability variables. None of the interest variables received a significant loading whereas PMA Number is the only ability variable without such a loading.

This factor can be considered as a factorially collapsed version of the domain explored by Thurstone (**30**) and his associates (**32**) leading to the establishment of the PMA tests used in this study. Since there is an extensive literature pertaining to this domain and its factorial composition (**6, 7, 9, 24, 30**), it does not require discussion here. It may be equated with Cattell's factor T.I: General Ability.

Factor C

Examination of the significant variables shows Factor C, like Factor A, as a bipolar preference factor with none of the ability variables significantly loaded.

This factor opposes preferences for "developing, discovering, investigating, exploring, etc.," and occupations popularly supposed to provide such opportunities, to preferences for "selling, collecting, interviewing, convincing, etc." It resembles Thurstone's Scientific Interests factor (**29**), which Cattell (**9**) has included with Strong's Science factor (**27**) in his factor QI.IIa: "Thoughtful interest in understanding nature." This label fits the positive pole of Factor C rather well, but does not convey the nature of the negative pole. The central theme of the preferences making up the negative pole could be identified as "being the centre of attention." The activities of selling, interviewing, entertaining with tricks of magic, playing music, etc., all put the "actor" in the centre of the stage. This interpretation makes the loading of KV Musical more intelligible by its implication that music is a means to an end in the same way that studying public speaking is.

Factor C may then be equated with Cattell's Factor QI.IIa and labelled: "Thoughtful interest in understanding nature *v.* being the centre of attention."

Factor D

This factor is the first on which both preference and ability variables received significant loadings. It extends in a positive plane only.

This factor involves activity preferences for "determining costs, typing, cataloguing, compiling, sorting, working with figures, mental arithmetic, etc." and superior computational ability. If attention is restricted to the preference aspect of this factor, it resembles those defined by Thurstone (**29**) as "Business interests," by Lurie (**21**) as a "Philistine" factor, and by Strong (**27**) as the "Office activities" cluster. This is the factor which Cattell calls "Philistine go-getting *v.* aesthetic interests"—his factor QI.IVa. Since Factor D of this study did not show bipolarity of the type implied by the above label of Cattell's, the alternative title "orderly-systematic" seems more appropriate.

The ability variables with significant loadings on this factor define the well-established Numerical Ability factor. The studies of Spearman (**26**), Thurstone (**30**), and Goodman (**15**), among others, have confirmed its existence. It is classified by Cattell as Factor T.VI: Numerical Ability.

This is the first of four factors in this study which support the hypothesis that interests and abilities are but aspects of more central personality dimensions. Factor D seems to illustrate the convergence of a well-defined ability dimension and a well-defined preference dimension.

Factor E

This factor is a bipolar preference factor and the fourth "simple" factor.

It emphasizes verbal activities at the positive pole ("poet, writer, journalist, reading theories of an ideal world, working mainly with ideas, writing, etc."), and manipulation of materials at the negative pole ("drawing, designing, painting, working with wood-working tools, jig-saw puzzles, shopwork, etc."). It resembles Thurstone's "interest in language" factor (**29**), the factor that Strong (**27**) called "Things *v.* People," and Cattell's interest factor entitled "Verbal persuasion *v.* practical control of materials"–Factor QI.IIIa. In this study Factor E might more properly be called "Verbal activity *v.* manipulation of materials."

Factor F

This is the second complex factor to emerge from the analysis; unlike the first complex factor (Factor D), it is bipolar.

In terms of the criteria established for this study, only one variable, DAT Abstract Reasoning, receives a significant positive loading on this factor. However, both KV Musical and PMA Space received loadings in excess of .22 (equivalent to the $P = .01$ level of significance) and will be used to establish a more adequate, though tentative, basis for interpretation of the positive pole.

This factor bears a resemblance to Lurie's (**21**) religious interests factor and to a factor involving high religious and social values and low aesthetic values defined by Ferguson, Humphrey, and Strong (**13**). Its equivalent in Cattell's catalogue is probably QI.V–"Socialized religion *v.* irreligious aesthetic interests." However, the above factors do not include any ability measures and Factor F does. The spatial cognitive component of Factor F is related to the factor that Cattell labels "Spatial-visual ability" (Factor T.VI). This ability is defined by Thurstone (**30**) as his S Factor, by Schiller (**24**) as spatial ability, and appears in Estes' (**10**) analysis of form-board, wiggly block, and intelligence tests.

The appearance of PMA Word Fluency on the negative pole, unsupported by either DAT Verbal Reasoning or PMA Verbal Meaning, tends to suggest that the "Socialized Religion" preference of this factor is associated with the verbal fluency sub-factor (Thurstone's W Factor) that Cattell includes among those verbal factors comprising his Factor T.II: Verbal ability. Cattell draws attention to the fact that a measure of ability (a word association test) has a demonstrated relationship to the temperamental trait, Surgency *v.* Agitated Melancholic Desurgency. His summary description of this temperamental factor reads in part: "All factorizations stress cheerful joyousness, gregariousness, friendly assertiveness, and talkativeness, adaptability, quick resourcefulness, humor that

tends to wit, and (less definite) sympathy, curiosity, and trustfulness" (9, p. 484).

This description of the surgency pole of the factor, with which a verbal fluency test has a high positive loading, is not incongruent with the preferences involved in the negative pole of Factor F (looking after, taking care of, training, teaching, helping, etc.) on which a word fluency test also shows a high loading. These relationships are cited because they suggest a possible convergence of ability, interest, and temperamental variables considerably beyond the level of those being explored in this study.

Factor G

This is the third of the complex factors, and the second on which sex shows a significant loading. Although apparently bipolar, this factor is not too well defined, since only one variable received a significant negative loading. However, KP Practical had a loading in excess of .22 and will be included in the negative pole of this factor.

Factors G and H share many interesting features. For example, sex has a positive loading on G but a significant negative loading on H, while KP Sociable shows significant positive loadings on both factors. Both G and H are complex factors, in that ability and preference variables have significant loadings on both dimensions. Finally, it is to be noted that these two factors are orthogonal to one another. Factor H will be presented, therefore, before either factor is interpreted.

Factor H

This factor is clearly bipolar. The positive pole is defined by both interest and ability variables, with the emphasis on the latter. The negative pole is defined by the sex variable and PMA Memory.

Examination of the variables with significant loadings on these last two factors may suggest that Factor G is a bipolar sex preference factor and Factor H a bipolar sex ability factor. It is true that the majority of variables with significant loadings on Factor G are preference variables and the majority of those on H ability variables. However, this interpretation would appear to oversimplify these factors.

The variable KP Sociable shows a significant loading on both factors, and in both the loading is positive. The emphasis in this variable on socially active self-assertive roles suggests that both factors may be related to that family of factors labelled by Cattell as Factor QP.VI: "Confident self-assertion." This factor subsumes factors established through the use of questionnaire and self-inventory data by Layman (20), Mosier (22), and others. Cattell suggests in his discussion of this factor

that it may on further analysis turn out to be two or more factors. The present results suggest that this is the case.

Factor G includes PMA Reasoning among its defining variables. This variable is a measure of what Burt (6) has called Logical Ability, and what Thurstone (30) calls D, or deductive ability. Factor H shows significant loadings for three ability variables. Its positive pole may be interpreted as involving a composite of numerical and spatial-visual ability, the negative pole as including a memory component.

Finally, it is to be noted that sex is positively loaded on Factor G, negatively on Factor H. This suggests that Factor G defines a personality dimension that differentiates between typical and atypical females, and Factor H a dimension that differentiates between typical and atypical males. Typical females would be defined by the constellation of abilities and interests defining the positive pole of Factor G, typical males by the positive pole of Factor H.

Summary

This study is an exploratory investigation of potential relationships between patterns of ability and of interest. Previous research, though not conclusive, suggested that substantial relationships might exist, and theoretical considerations implied that such relationships could be expected.

The centroid factor analysis of a battery of ability and interest measures produced eight factors. Upon rotation to simple structure one of these factors was defined as an ability factor, three as preference factors, and four as composite factors involving both ability and interest variables.

The results are interpreted as showing that abilities and interests are related, though not, perhaps, causally or in one-to-one fashion, as some investigators have presumed. This research suggests that abilities and interests converge, in various constellations, on relatively independent behaviour dimensions. For theoretical reasons these dimensions may best be defined as overlearned behaviour patterns, that is, "traits."

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A Comprehensive Dictionary of Psychological and Psychoanalytical Terms. By HORACE B. ENGLISH and AVA CHAMPNEY ENGLISH. Toronto: Longmans, Green & Co., 1958. Pp. xiv, 594. $8.80.

"AS DULL as a dictionary" has been an obsolete simile ever since the great Oxford Dictionary appeared, and it is equally misleading in the case of the present volume. Admittedly, Professor English, with the collaboration of his wife and the help of six distinguished consultants, has given us the varied meanings of over 13,000 psychological and psychoanalytic terms, and this is no small service. But the book goes much further than that, as its sub-title, *A Guide to Usage*, suggests. The senior author has been engaged with the psychological vocabulary for more than thirty years, and has formed opinions about our terminological practices which he freely shares with his readers. In editorial comments, clearly distinguished from the definitions proper, he shows how and why certain usages lead to confusion, and often suggests better ones. This makes his dictionary not merely a reference work but an enjoyable and highly instructive browsing-ground.

Particularly heart-warming to this reviewer are his denunciations of those pretentious polysyllables which threaten to drive clear, simple English out of much psychological writing. For some authors even statements of fact cannot be repeated but must be "replicated," shocked animals "incur traumatization," and no one ever thinks anything at all, but invariably "hypothesizes" it. As English points out, the function of such expressions is rather to show that one belongs to the proper inner circle than to express a clear idea. In his Preface he writes: "In the face of the neologistic fertility that plagues psychology . . . I have not hesitated to suggest terminological contraception or even—dare we say?—verbocide." Every journal editor will applaud him; he is worthy of his surname.

The vast amount of information contained in these 600 pages is not limited to meanings and usages; study of the varying senses in which a term has been employed inevitably provides a valuable perspective on the hypotheses and theories concerned. To read, for example, the more than two pages devoted to *reinforcement* and its compounds gives one, not only a clearer notion of the tangled history and meanings of the concept, but also insight into the relevant formulations of Pavlov, Hull, and others, the differences among them, and the numerous experimental procedures in which reinforcement plays a part. If the reader then turns to the article *theory-begging* he will also receive a salutary caution against

assuming that the inferred process often called reinforcement has the same factual status as the operation of reinforcing a response.

The above are two of some three hundred short general articles which are scattered through the dictionary in the manner of H. W. Fowler (whom English evidently admires) and which account for much of its usefulness and charm. In these, while defining and comparing a number of related terms, the author brings his scholarship, his critical sharpness, and often his delightful wit to bear on the concepts referred to. Under *bogus erudition*, for instance, we meet that blessed phrase "traumatophilic diathesis," whose use will infallibly raise the clinician's prestige by preventing others from recognizing mere "accident proneness." The disorder called *Xenoglossophilia*, we learn under the X's, leads to the use of strange, pretentious, or foreign words when simpler ones would serve; and English aptly adds that the term itself is the product of the disorder referred to. The next entry, *Xenoglossophobia*, is defined as "a morbid fear of foreign languages—a very common affliction of graduate students." It is tempting to quote these pungent sallies, but they are, after all, only the embroidery on a work of serious purpose. Those who turn to the articles on behaviour, emotion, learning, motivation, and scores of other central concepts will find treatments that are solid, thoughtful, splendidly condensed, and in most cases beyond reasonable criticism. There is nothing bogus about the erudition of Professor English; the breadth of his knowledge is as remarkable as the acuteness of his discriminations.

The dictionary is well bound and clearly printed, and the employment of varied type-styles for sources, synonyms, cross-references, and so on, makes it pleasant and easy to use. Its publication is a major contribution towards clearer communication in our turgid and jargon-ridden discipline, and psychologists, particularly any who hope to write for publication, should secure it in haste and keep it at hand.

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